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**AGE, CORRELATION, AND BIOSTRATIGRAPHY OF  
THE UPPER TOCUYO (SAN LORENZO) AND POZÓN  
FORMATIONS, EASTERN FALCÓN, VENEZUELA**

By

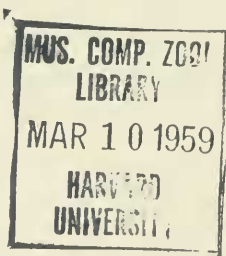
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# AGE, CORRELATION, AND BIOSTRATIGRAPHY OF THE UPPER TOCUYO (SAN LORENZO) AND POZÓN FORMATIONS, EASTERN FALCÓN, VENEZUELA

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## ABSTRACT

H. H. Renz (1948) proposed a biostratigraphical subdivision of the Agua Salada group, eastern Falcón, Venezuela, based almost entirely on the occurrence of benthonic Foraminifera. The present work critically re-examines this biostratigraphy in the light of new evidence from a detailed traverse along the Pozón-El Mene Road. The stratigraphical distribution of both benthonic and planktonic Foraminifera has been investigated. Evidence from this traverse shows that a direct correlation between the planktonic foraminiferal biozones used in Trinidad and the subdivisions of Renz can be achieved. Furthermore, whereas, in southern Trinidad, Miocene sediments above the *Globorotalia menardii* Zone, Lengua formation are devoid of planktonic Foraminifera, corresponding sediments in eastern Falcón often contain abundant planktonic faunas. Investigations show that, using planktonic Foraminifera, a further subdivision of these higher sediments is possible. Three new biozones are proposed within these middle to upper Miocene sediments.

Since the section in eastern Falcón is largely undisturbed by tectonic complications, a confirmation of H. M. Bolli's (1950, 1957) planktonic zonation based on surface and subsurface sections within the Cipero-Lengua formations (southern Trinidad) is possible. Bolli's biozones are shown to have more than local validity whereas the benthonic foraminiferal zonation of Renz is strongly influenced by ecological conditions.

The age and a trans-Atlantic correlation of these eastern Falcón Miocene sediments is discussed in the light of evidence seen recently in Sicily and Malta.

A number of evolutionary studies have been made within the Oligocene and Miocene Orbulinidae and Globorotaliidae, and five lineages have been distinguished and are discussed. In some of these lineages, evolutionary changes appear to have occurred in a repetitive manner. The first occurrence and evolution of *Globigerina bulloides* is discussed. Reference is also made to the evolution and first occurrence of the genus *Orbulina* d'Orbigny, whilst the wall structure and morphology of the genus *Sphaeroidinella* Cushman, 1927 is discussed in some detail.

One hundred seventy-four species of benthonic Foraminifera (including two new species) and 72 species or subspecies of planktonic Foraminifera (including ten new forms) are described or discussed.

The name Tocuyo is substituted for San Lorenzo, a term which is pre-occupied by the name San Lorenzo formation in California (Arnold, 1906).

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## I. INTRODUCTION


### PAST WORK

In 1948, H. H. Renz made a detailed study of the benthonic Foraminifera of the Agua Salada group, District of Acosta, eastern Falcón, Venezuela, (Maps 1, 2). He erected a biostratigraphic term based almost entirely on the stratigraphic distribution of these bottom-living forms. Renz, in his detailed study, also reviewed the biostratigraphical and lithostratigraphical studies of many earlier workers, notably Thomas (1924), Senn (1935), Cushman and Renz (1941), and Renz (1942). Much of the stratigraphical terminology used by these earlier workers has become obsolete and superseded by Renz's (1948) detailed and comprehensive work.



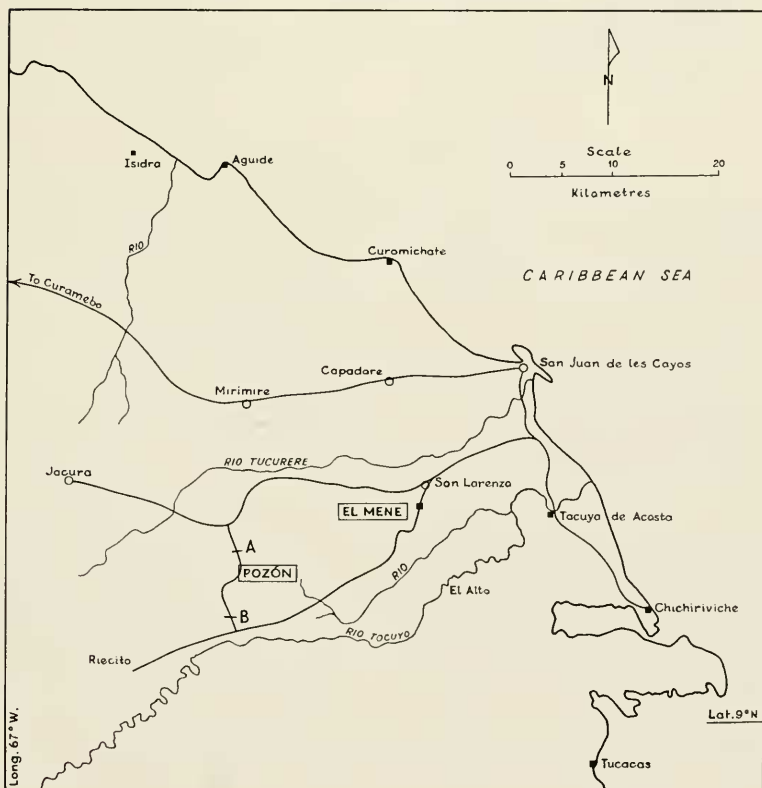
MAP 1. Geographical position of Eastern Falcón and Trinidad.

**LEGEND:** Area of map 2

shaded thus 

MAP 2.

Sketch map of the Eastern Falcón, Venezuela, Region  
showing the geographical position of the  
POZÓN - EL MENE ROAD SECTION (A - B)



Renz (1948, p. 8) pointed out that the term "Agua Salada Group" first appeared in a paper published in 1937 (Wiedenmayer) although this term has been used as early as 1919 in private reports to oil companies by M. L. Thomas.

The Agua Salada group has been divided on lithological grounds into two formations, *i.e.*, an older San Lorenzo formation<sup>1</sup> (type locality at El Mene de Acosta) and a younger Pozón formation (type locality at Pozón). Renz (1948 pp.8-27) also reviewed the lithology of these two formations (including work by J. C. Griffiths) and pointed out that the following lithological subdivisions have been generally recognized by field geologists employed by oil companies operating in the area:—

#### OJO DE AGUA FORMATION

Agua Salada group	{	Huso Clay member	}	Pozón Formation
		Husito Marly-Clay member		
		Policarpio "Greensand" member		
	{	Menicito Clay member	}	San Lorenzo Formation (Tocuyo fm.)
		El Salto Sand member		

#### GUACHARACA FORMATION

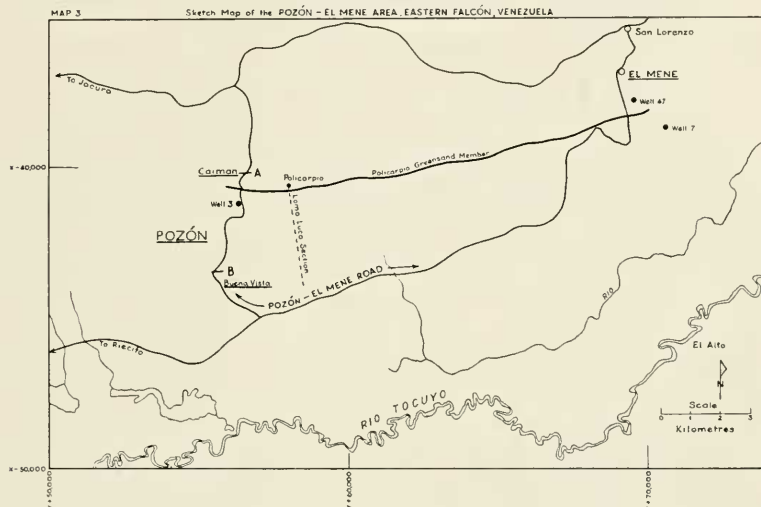
Renz (1948, pp.38-76) erected the following biostratigraphical subdivisions for the San Lorenzo and Pozón formations based almost entirely on the occurrence of benthonic Foraminifera:—

<u>OJO DE AGUA FORMATION</u>				
<i>Robulus senni</i> Zone	}		}	Pozón Formation
<i>Marginulinopsis basispinosus</i> Zone				
<i>Valvulineria herricki</i> Zone				
<i>Globorotalia fohsi</i> Zone				
<i>Siphogenerina transversa</i> Zone	}		}	San Lorenzo Formation (Tocuyo fm.)
<i>Robulus wallacei</i> Zone				
" <i>Uvigerinella</i> " <i>sparsicostata</i> Zone (part)				

#### GUACHARACHA FORMATION

<sup>1</sup> See Appendix I, concerning the validity of this formational name and proposal of substitution of the name Tocuyo for San Lorenzo.

The type section of the Pozón formation was chosen by Renz along the Loma Luca traverse (see Map 3) whilst the type section for the San Lorenzo formation was chosen at El Mene de Acosta.



Renz (1948, pp.69-76) further subdivided his *Robulus senni* Zone into three "Zonules":—

*Elphidium poeyanum*-*Reussella spinulosa* Zonule,

*Textularia panamensis* Zonule,

*Vaginulinopsis superbis*-*Trochammina* cf. *pacifica* Zonule

but pointed out that these zonules could be recognized only in the Pozón area and not in the El Mene area to the east of Pozón (see Map 2). The relationship of Renz's biostratigraphical subdivisions to the generally accepted lithological subdivisions is shown on the right-hand side of Chart 1 and on Map 4.

Renz (1948, p.38 *et seq.*) considered the San Lorenzo formation to be of middle and upper Oligocene age whilst the Pozón formation was considered to range from upper Oligocene to Miocene (Tortonian) times. However, when assessing these ages ascribed by Renz, it is necessary to remember that Renz (1948, p. 26) placed

the Aquitanian in the Oligocene and considered the Miocene to commence with the Burdigalian stage. The present writer discusses these age relationships in some detail at a later stage in this study, but would state here that, following the recommendation of the U. S. Geological Survey, he regards the Aquitanian as basal Miocene.

#### SCOPE OF THE PRESENT WORK AND MATERIAL

Whereas in eastern Falcón the biostratigraphical subdivisions of the Agua Salada group were, previous to this study, made in terms of mainly benthonic Foraminifera (Senn, 1935; Cushman and Renz, 1941; Renz, 1948), in southern Trinidad the emphasis has been to use planktonic Foraminifera (mainly because of their abundance) for the zonation of the Cipero and Lengua formations (Cushman and Stainforth, 1945; Stainforth, 1948a; Bronnimann, 1951; Bolli, 1950, 1951, 1957) so that a direct correlation between the areas was not possible previous to this study.

It was suggested to the writer by Dr. H. G. Kugler and Dr. H. M. Bolli that an investigation of the planktonic Foraminifera of the Agua Salada group would permit a direct comparison to be made between the benthonic biostratigraphy of Renz and the planktonic biostratigraphy used in southern Trinidad. This investigation has now not only provided a confirmation of the succession of biozones recognized in Trinidad but has also shown that these planktonic biozones have more than local validity. The eastern Falcón succession (in contrast to the succession in southern Trinidad) appears to be complete and not so much disturbed by penecontemporaneous slumping and reworking of Foraminifera. Consequently, the present study has enabled some further refinements to be made to the planktonic biostratigraphy of the Caribbean Miocene. This study also emphasizes the value of planktonic Foraminifera for long distance correlation of heterotopic sediments.

This work is based on the faunal analysis (of both planktonic and benthonic Foraminifera) of over 700 closely spaced auger and pit samples collected by Dr. R. Muhlemann from a detailed traverse, along or off-set, from the north to south section of the Pozón-El Mene Road between Caiman and Buena Vista (Maps 1,

2, 3 and 4). Map 4 shows in detail the positions of Muhlemann's samples which are, in general, equally spaced and follow consecutively between the "key" samples actually indicated. The geographical relationship of this section as shown on Map 4 is given by reference to the letters "A" and "B" on Maps 2 and 3.

This Pozón-El Mene Road section, which is about 2,000 metres west of Renz's Loma Luca section, extends from the upper part of the San Lorenzo (Tocuyo) formation through the Pozón formation into the overlying Ojo de Agua formation. Since this Pozón-El Mene Road traverse was sampled in detail and each sample collected at intervals of approximately five metres, it has been possible to make a close check on the ranges of the Foraminifera described in this paper. Also it has been possible to make some evolutionary studies for some groups of planktonic Foraminifera.

In addition to the samples collected by R. Muhlemann from the Pozón-El Mene Road, the original samples used by Renz from the Loma Luca (Renz, 1948—Table No. 4) were available to the writer so that it was possible to note with precision the factors governing the position of Renz's various zonal boundaries. Furthermore, samples from the nearly completely cored Pozón Well 3 and El Mene Wells 7 and 47 were also investigated.

The writer (Blow, 1956) published a preliminary correlation between the two biostratigraphies, and Chart 1 shows this correlation in the light of further evidence. Map 4 shows in detail the relationship of the zonal boundaries of both types of biostratigraphies to each other and in conjunction with the sequence of samples studied along the Pozón-El Mene Road traverse.

## II. PLANKTONIC BIOSTRATIGRAPHY OF THE UPPER TOCUYO<sup>2</sup> AND POZÓN FORMATIONS

Based on the stratigraphical occurrence of planktonic Foraminifera the author has been able to recognize the following biostratigraphical subdivisions of the upper part of the Tocuyo formation and the Pozón formation as seen in the detailed traverse along,

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<sup>2</sup> Hereafter, Tocuyo, see Appendix, will be used in place of San Lorenzo formation.

AGE	SOUTHERN TRINIDAD, B. W. I.			EASTERN FALCÓN, VENEZUELA			
	FORMATION	BIOZONES (BOLLÉ et al.)	LITHOLOGY	LITHOLOGY	BIOZONES (BOLLÉ)	BIOZONES (RENZ 1946)	FORMATION
Pliocene	MORNE L'ENFER		Sands and Silts		<i>Globigerina bulloides</i> Zone	C/O DE AGUA FMT.	
Miocene	FOREST FORMATION	Mainly rather poor calcareous benthonic faunas	Alternating Silts and Sands	Hua Clay Member		<i>Polysius sena</i> Zone	POZÓN FORMATION
			Lower Forest Clay Unconformable contact		<i>Globorotalia senaensis</i> Zone	(Including 5 Senales)	
			Non-Calcareous Silts, Sands and some Clays				
	CRUSE FORMATION	Arenaceous Facies Faunas	L. Cruse Non-Calcareous Clays	Hua Clay Member			
			L. Cruse - L. Sena transition		<i>Globorotalia senaensis</i> Zone		
			L. Sena - L. Sena transition				
	LENGUA FORMATION	<i>Globorotalia senaensis</i> Zone	MISSING OR REPRESENTED BY KARAHAT AND/OR RIO CLARO BOULDER BED	Calcareous Clays and Marls			
			KARAHAT		<i>Globorotalia senaensis</i> Zone		
			MISSING				
	KARAMAT FMT.	<i>Globorotalia senaensis</i> Zone	MISSING				
Pliocene	CIPERO FORMATION	<i>Globorotalia senaensis</i> Zone	MISSING	Polcarrio "Ind" Member			SAN LORENZO FORMATION
			MISSING				
			MISSING				
	NARIVA FMT.	<i>Globorotalia senaensis</i> Zone	MISSING				
			MISSING				
			MISSING				
	KARAMAT FMT.	<i>Globorotalia senaensis</i> Zone	MISSING				
			MISSING				
			MISSING				
	NARIVA FMT.	<i>Globorotalia senaensis</i> Zone	MISSING				
Pliocene	CIPERO FORMATION	<i>Globorotalia senaensis</i> Zone	MISSING	Polcarrio "Ind" Member			SAN LORENZO FORMATION
			MISSING				
			MISSING				
	NARIVA FMT.	<i>Globorotalia senaensis</i> Zone	MISSING				
			MISSING				
			MISSING				
	KARAMAT FMT.	<i>Globorotalia senaensis</i> Zone	MISSING				
			MISSING				
			MISSING				
	NARIVA FMT.	<i>Globorotalia senaensis</i> Zone	MISSING				

CHART 1. CORRELATION OF EASTERN FALCÓN WITH SOUTHERN TRINIDAD

Tocuyo should be substituted for San Lorenzo formation.  
 (Note: No vertical scale implied and intervals represented diagrammatically.)

CHART 2 -

Note: The term *San Lorenza* should be changed to Tokuyi. Read *Sarracenia latifrons* in list. Move 3rd vertical to right middle of next column in top horizontal.

S - C = Scarce to Common  
C - A = Common to Abundant

## MAP. 4

SECTION



or off-set from, the Pozón-El Mene Road between Caiman and Buena Vista (see Maps 2, 3, and 4—points marked “A” and “B”):—

10. *Globigerina bulloides* Zone
9. *Sphaeroidinella seminulina* Zone
8. *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone
7. *Globorotalia mayeri* Zone (*s.l.*)  $\left\{ \begin{array}{l} \text{Gr. mayeri/G. nepenthes} \\ \text{Gr. mayeri/Gr. linguaensis} \end{array} \right. \begin{array}{l} \text{Subzone} \\ \text{Subzone} \end{array}$
6. *Globorotalia fohsi robusta* Zone
5. *Globorotalia fohsi lobata* Zone
4. *Globorotalia fohsi fohsi* Zone
3. *Globorotalia fohsi barisanensis* Zone
2. *Globigerinatella insueta* Zone (*s.l.*)  $\left\{ \begin{array}{l} \text{G. insueta/G. bispherica} \\ \text{G. insueta/G. triloba} \end{array} \right. \begin{array}{l} \text{Subzone} \\ \text{Subzone} \end{array}$
1. *Catapsydrax stainforthi* Zone

The base of the Pozón formation (as represented by the base of the Policarpio “Greensand” member) occurs within the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone. The zonal boundaries of the zones are defined on Map 4 and the direct correlation of these planktonic zones with Renz’s (1948) benthonic zones is also given on the same Map.

The planktonic zones and their associated subzones are discussed below and the diagnostic faunal elements of each zone are briefly noted. The complete benthonic and planktonic foraminiferal content of each interval is summarized on Chart 2 and Chart 3 respectively.

1. *Catapsydrax stainforthi* Zone, Tocuyo formation (in part)

This zone is defined by the limited occurrence together of *Catapsydrax dissimilis* (Cushman and Bermudez) and *Globigerinatella insueta* Cushman and Stainforth. *Globoquadrina rohri* (Bolli) only occurs in the lower part of this interval. *Catapsydrax unicavus* Bolli, Loeblich, and Tappan does not range higher than the top of this zone and although *Catapsydrax stainforthi* Bolli, Loeblich, and Tappan is not limited to this interval, it is a conspicuous member of the zone's fauna.

The base of this zone is not seen in the Pozón-El Mene Road traverse but, from evidence seen in the subsurface sections of Pozón Well 3 and El Mene Wells 7 and 47, the lower boundary of the *Robulus wallacei* Zone (Renz, 1948, p. 45) still occurs within the co-existence of *Catapsydrax dissimilis* and *Globigerinatella insueta* so that the topmost part of Renz's "*Uvigerinella*" *sparsicostata* Zone can be correlated with the basal part of this planktonic biozone.

2. *Globigerinatella insueta* Zone (*s.l.*), Tocuyo formation (upper part) and Pozón formation (lower part)

This zone spans the uppermost part of the Tocuyo formation and the basal part of the Pozón formation as seen in the Pozón area of eastern Falcón.

The writer recognizes two subzones within this zone which are based on the evolution of *Globigerinoides bispherica* Todd (as emended by Blow, 1956, p. 62) from *Globigerinoides triloba triloba* (Reuss). The zone is distinguished by the presence of *Globigerinatella insueta* Cushman and Stainforth but *Catapsydrax dissimilis* (Cushman and Bermudez) and *Catapsydrax unicavus* Bolli, Loeblich, and Tappan are absent.

2a. *Globigerinatella insueta*/*Globigerinoides triloba* Subzone

This subzone is separated from the overlying subzone by the absence of *Globigerinoides bispherica*. *Catapsydrax stainforthi* occurs in this interval but does not range to the top of the subzone. *Globigerinoides diminuta* Bolli first occurs in the upper part of the interval but does not become common until the interval of the

overlying *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone. *Globigerinoides triloba triloba* (Reuss) is particularly common in this interval.

*Robulus wallacei* (Hedberg) becomes extinct in this interval and last occurs in Sample RM 19179 (see Map 4).

## 2b. *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone

This subzone is characterized by the occurrence together of *Globigerinatella insueta* and *Globigerinoides bispherica*. The evolution of *Orbulina* and *Biorbulina* from *Globigerinoides bispherica* via *Porticulasphaera glomerata* (Blow) and *Porticulasphaera transitoria* (Blow), respectively, occurs within the upper part of this subzone (Blow, 1956).

*Globigerinoides diminuta* Bolli also characterizes this interval and, although it ranges from the uppermost part of the underlying subzone, it does not range into the overlying *Globorotalia fohsi barisanensis* Zone. *Globorotalia menardii archeomenardii* (Bolli) first appears within this subzone.

### *Globorotalia Fohsi* "Zone" (s.l.), Pozon Formation (in Part)

Before discussing the next four zones, which are based on the subspecies of *Globorotalia fohsi*, it is necessary to outline a short historical review of Bolli's work (Bolli, 1950, 1957) with reference both to the various subspecies of the species and to their biostratigraphical usage.

Bolli (1950) recognized that certain other types of *Globorotalia* show evolutionary relationships to the form described byushman and Ellisor (1939) as *Globorotalia fohsi*. Bolli established, by detailed study of continuous surface and subsurface sections in the Cipero formation of southern Trinidad, that there was a gradational sequence extending from a form recorded by LeRoy (1939) as *Globorotalia barisanensis* to a form described by Bermudez (1949) as *Globorotalia lobata*. Bolli (1950) considered these two latter types as subspecies of the "central type" *Globorotalia fohsi*; at the same time Bolli also recognized that the evolutionary trend continued beyond the subspecies "lobata" and distinguished a fourth and final subspecies as *Globorotalia fohsi robusta*. These phylogenetic studies were adopted by other authors (Bronnimann,

1951a) who used the occurrence of these various subspecies to define subzones of the *Globorotalia fohsi* Zone. Later (Bolli, 1957), these subzones were afforded the biostratigraphical rank of zones. The present writer agrees with this later view since it has become established that the intervals in question can be recognized not only in various parts of Trinidad but also in eastern Falcón. Furthermore, since the zonation is based on a well-defined evolutionary sequence, biological principles suggest that the zonal boundaries should be isochronous within the limits imposed by the rates of faunal migration and genetic interchange.

The term *Globorotalia fohsi* "Zone" (*s.l.*) is retained in the present work purely as a convenience when discussing the range of some of the Foraminifera.

3. *Globorotalia fohsi barisanensis* Zone, Pozón formation (in part)

This zone is distinguished by the presence of *Globorotalia fohsi barisanensis* (LeRoy), *Orbulina suturalis* Bronnimann, *Orbulina universa* d'Orbigny, and *Borbulina bilobata* (d'Orbigny) combined with the absence of *Globigerinatella insueta* Cushman and Stainforth. *Globigerinoides bispherica* Todd persists only into the extreme basal part of the zone. Below this zone, and within the underlying *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi barisanensis* is small and with a generally rather lobulate periphery with fairly well-incised sutures. However, in this zone, *Globorotalia fohsi barisanensis* has less deeply incised sutures and the periphery is practically nonlobulate. Furthermore, the ventral side shows a tendency to be rather more definitely vaulted than in the earlier forms of the subspecies.

*Globorotalia scitula scitula* (Brady) appears for the first time in the uppermost part of this zone.

4. *Globorotalia fohsi fohsi* Zone, Pozón formation (in part)

This zone is characterized by the presence of *Globorotalia fohsi fohsi* Cushman and Ellisor and *Globorotalia menardii prae-menardii* (Cushman and Stainforth). *Globorotalia scitula gigantea* Blow, subsp. nov. appears in the upper part of this interval for the first time.

*Siphogenerina transversa* Cushman becomes extinct at about the middle part of this interval (Sample No. RM 19376—see Map

4) whilst *Valvulineria herricki* (Hadley) first appears in its uppermost part (Sample No. RM 19381).

H. H. Renz (1948) recognized a "*Globorotalia fohsi* Zone" between his *Siphogenerina transversa* and *Valvulineria herricki* Zones and reference to the sample originally used by Renz (see Renz, 1948, Table No. 4-samples filed in the collections of Texaco Trinidad Inc., Pointe-à-Pierre) showed that the samples referred to by him as his "*Globorotalia fohsi* Zone" contain forms referable to the subspecies *Globorotalia fohsi fohsi* Cushman and Ellisor and *Globorotalia fohsi lobata* (Bermudez). Hence it appears that the "*Globorotalia fohsi* Zone" of H. H. Renz is equivalent to part of the *Globorotalia fohsi fohsi* and the *Globorotalia fohsi lobata* Zones as used by Bolli (1957) and the present writer.

5. *Globorotalia fohsi lobata* Zone, Pozón formation (in part)

This zone is characterized by the presence of *Globorotalia fohsi lobata* and *Globorotalia menardii praemenardii*. *Globorotalia scitula gigantea* Blow, subsp. nov. is also present whilst *Globigerina bulbosa* LeRoy and *Sphaeroidinella seminulina kochi* (Caudri) appear for the first time within this zone.

6. *Globorotalia fohsi robusta* Zone, Pozón formation (in part)

This zone is distinguished by the presence of *Globorotalia fohsi robusta* Bolli. *Globorotalia menardii menardii* (d'Orbigny) develops from *Globorotalia menardii praemenardii* (Cushman and Stainforth) in the middle part of this interval, and *Sphaeroidinella dehiscens subdehiscens* Blow, subsp. nov. occurs for the first time in the uppermost part of this zone. *Sphaeroidinella seminulina kochi* (Caudri) becomes fairly common in this zone.

7. *Globorotalia mayeri* Zone (*s.l.*), Pozón formation (in part)

This zone is characterized by the continuing presence of *Globorotalia mayeri* Cushman and Ellisor after the extinction of *Globorotalia fohsi robusta*. *Globoquadrina altispira globosa* Bolli reappears from the base of the interval and although *Globorotalia linguaensis* Bolli first appears in the topmost part of the underlying interval it only forms a significant component of the fauna in this zone.

The writer recognizes two subzones within this interval in eastern Falcón:

7a. *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone

This subzone is characterized by the co-existence of *Globorotalia mayeri* and *Globorotalia linguaensis* combined with the absence of both *Globorotalia fohsi robusta* and *Globigerina nepenthes* Todd. *Globigerinoides bollii* Blow, sp. nov. first occurs at the base of the subzone.

7b. *Globorotalia mayeri*/*Globigerina nepenthes* Subzone

This subzone is characterized by the co-existence of *Globorotalia mayeri* and *Globigerina nepenthes*. *Globigerinoides bollii* and *Sphaeroidinella dehiscens subdehiscens* both become common within this interval.

*Margulinopsis basispinosus* (Cushman and Renz) first occurs in sample RM 19671 within this interval (see Map 4).

8. *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation (in part)

This zone is distinguished by the continuation of *Globigerina nepenthes* Todd after the extinction of *Globorotalia mayeri* Cushman and Ellisor. *Globorotalia menardii menardii* is often abundant and typical. *Globorotalia acostaensis* Blow, sp. nov. occurs for the first time within this zone whilst *Globigerina bulloides* d'Orbigny develops from *Globigerina praebulloides* Blow, sp. nov. in the middle part of this interval.

Occasional specimens of *Globigerina apertura* Cushman have also been observed in the upper part of this zone. Transitional forms to *Globorotalia menardii miocenica* Palmer also appear at the top of this zone.

9. *Sphaeroidinella seminulina* Zone, Pozón formation (in part)

This zone is marked by the continuing presence of both subspecies of *Sphaeroidinella seminulina*, i.e., *Sphaeroidinella seminulina seminulina* (Schwager) and *Sphaeroidinella seminulina kochi* (Caudri), but it is highly likely that the latter subspecies becomes extinct before the former.

Although the possibility exists that the upper limit of this zone is influenced to some extent by facies change, evidence seen

in two subsurface sections on the Island of Cubagua (see Map 1) also shows the same extinction of both subspecies of *Sphaeroidinella seminulina* within similar planktonic assemblages as seen in this Pozón-El Mene Road section. Also, in the Cubagua subsurface sections there is no apparent change of facies.

#### 10. *Globigerina bulloides* Zone, Pozón formation (in part)

Following the disappearance of *Sphaeroidinella seminulina* (Schwager) there is no further change in the composition of the planktonic faunas which tend to become rather impoverished in the section under consideration. However, some isolated samples show fairly rich planktonic assemblages which contain typical specimens of *Globorotalia menardii menardii*, *Globigerina bulloides*, *Orbulina universa*, *Globigerinoides triloba immatura*, and *Globigerinoides bollii* amongst others.

Occasional specimens of *Sphaeroidinella dehiscens subdehiscens* occur, but no specimens of the *Sphaeroidinella seminulina* group have been observed.

The designation of this interval must be regarded as only provisional since *Globigerina bulloides* continues to the present time. Investigations of uppermost Miocene/Pliocene planktonic assemblages from other areas might show that another planktonic species with a more rigorously defined biostratigraphical occurrence may prove to be a better zonal index.

### III. FACIES VARIATION IN THE UPPER TOCUYO AND POZÓN FORMATIONS

There are some differences in the stratigraphical distribution of benthonic Foraminifera as recorded by H. H. Renz (1948) from his Loma Luca section and that noted by the writer in the study of the Pozón-El Mene Road traverse. Most of these discrepancies in the Tocuyo and lower part of the Pozón formation do not appear to be of importance from the point of view of biostratigraphical interpretation. These minor variations in stratigraphical distribution are noted under "Occurrence" in the relevant parts of the Systematic Record associated with this work. However, in the upper part of the Pozón formation these discrepancies do become

important. Thus the writer has noted the occurrence together of *Marginulinopsis basispinosus* (Cushman and Renz) with *Valvulineria herricki* (Hadley) which was not recorded by Renz. Also, the occurrence of *Valvulineria herricki* is often only sporadic and seems to occur only under apparently limited ecological conditions. In general, it is often necessary to examine a number of samples from either a section or locality to decide, unambiguously, their position in the biostratigraphy of Renz. This is especially so in the upper part of the Pozón formation where the evidence suggests an approach to rhythmic or cyclic conditions of deposition.

Before discussing some of these effects of variation of environment on the stratigraphical distribution of benthonic Foraminifera it is useful to review the general conclusions drawn by Renz for the depositional conditions of the Tocuyo and Pozón formations. These conclusions are summarized below and show that there is an overall and generalized trend towards shallow-water conditions in the upper part of the Pozón formation.

Zone (Renz, 1948)

*Robulus wallacei* Zone  
(at El Mene)

Normal marine, open sea, deposition at medium depth (200-600 metres) along a continental shelf in tropical latitudes.

*Siphogenerina transversa*  
Zone  
(at El Mene)

Normal marine, open sea, deposition at medium depth (200-600 metres) along a continental shelf in tropical latitudes.

*Globorotalia fohsi* Zone  
(of Renz, 1948, at Pozón)

Normal marine, open sea, deposition at medium depth (200-600 metres) along a continental shelf in tropical latitudes.

*Valvulineria herricki* Zone  
(at Pozón)

Normal marine, open sea, deposition at medium depth (200-600 metres) along a continental shelf in tropical latitudes.

<i>Marginulinopsis basispinosus</i> Zone (at Pozón)	Normal marine, open sea, deposition at medium depth (200-600 metres) along a continental shelf in tropical latitudes.
<i>Robulus senni</i> Zone (at Pozón)	Normal marine environment at a shallow depth (littoral-neritic) of about 100 metres in tropical latitudes.
<i>Vaginulinopsis superbus</i> - <i>Trochammina</i> cf. <i>pacifica</i> Zonule (at Pozón)	Normal marine environment at a shallow depth (littoral-neritic) of about 100 metres in tropical latitudes.
<i>Textularia panamensis</i> Zonule (at Pozón)	Normal marine environment at shallow depths (neritic) of about 50 metres near a tropical coast.
<i>Elphidium poeyanum</i> - <i>Reussella spinulosa</i> Zonule (at Pozón)	Marine to brackish water lagoonal condition with very shallow, warm water conditions.

(Note: For the equivalence of the planktonic zones to those of Renz—see Chart 1 and Map 4).

The environmental conditions of the *Robulus wallacei* Zone and the *Siphogenerina transversa* Zone as seen in the Pozón-El Mene Road section at Pozón do not appear to be significantly different from the conditions seen at El Mene and as summarized above. However, a noteworthy feature of these zones in the Pozón area is the occurrence of intervals with assemblages of mainly large agglutinated species often with complex wall and chamber structures, such as: *Cyclammina cancellata* Brady, *Alveolavalvulinella pozonensis* (Cushman and Renz), *Gravellina narivaensis* Bronnemann, *Valvulina flexis* Cushman and Renz, *Alveolophragmium* spp., and robust species of *Haplophragmoides*. These assemblages are similar to the assemblages of the Nariva formation of southern Trinidad; but whereas the Nariva formation extends from the

*Globorotalia kugleri* Zone through the *Catapsydrax dissimilis* Zone and into the *Catapsydrax stainforthi* Zone, in eastern Falcón the similar assemblages extend stratigraphically higher into the *Globigerinatella insueta* Zone (*s.l.*). Stainforth (1948a, 1952a) considered these assemblages of agglutinated species to indicate a turbid water environment and Kugler (1953) related this turbid environment to the occurrence of turbidity flows in a subsiding trough. These assemblages of agglutinated forms from the *Catapsydrax stainforthi* Zone and the *Globigerinatella insueta* Zone (*s.l.*). Tocuyo and Pozón formations, occur several times and are separated by assemblages of calcareous forms, often with abundant planktonics, suggestive of a depositional depth between 200 and 600 metres. The writer considers that these assemblages of robust and complex agglutinated species represent periods of localized deepening and downwarping with minor turbidity flows giving rise to temporary turbid conditions. This view is supported by observations of Lowman (1949) who pointed out that certain agglutinated species (including *Cyclammina*) have an optimum depth occurrence of about 1400 metres in the Gulf of Mexico at the present day.

Above the *Marginulinopsis basispinosus* Zone, Pozón formation (*i.e.*, above the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone) and within the intervals of the *Robulus senni* Zone and the *Vaginulinopsis superbus*-*Trochammina* cf. *pacifica* Zonule as well as in the *Textularia panamensis* Zonule there occur frequent repetitions of faunal assemblages in the Pozón-El Mene Road section.

In the *Robulus senni* Zone and in the *Vaginulinopsis superbus*-*Trochammina* cf. *pacifica* Zonule these repetitions consist of intervals with *Uvigerina isidroensis* Cushman and Renz, *Bolivina imporcata* Cushman and Renz and *Bolivina simplex* Cushman and Renz, alternating with the "normal" zonal assemblages containing *Robulus senni* Cushman and Renz, *Vaginulinopsis superbus* (Cushman and Renz), *Cassidulina subglobosus* Brady, *Cibicides* spp., *Globigerina* spp., and *Globorotalia* spp.

In the *Textularia panamensis* Zonule a three-fold repetition occurs. Assemblages with *Eponides parantillarum* Galloway and

Heminway, *Nonion incisus* (Cushman), *Cancris sagra* (d'Orbigny), *Cibicides americanus* (Cushman), *Globigerina* spp., and *Globorotalia* spp. are followed by assemblages with *Uvigerina isidroensis* Cushman and Renz, *Bolivina imporcata* Cushman and Renz, and *Bolivina simplex* Cushman and Renz. This last assemblage is followed in turn by a mainly "arenaceous" assemblage with *Textularia panamensis* Cushman, *Textularia pozonensis* Cushman and Renz, and thin-walled *Trochammina* spp. It is considered that the *Uvigerina isidroensis*-*Bolivina imporcata*-*Bolivina simplex* assemblage represents an environment shallower than that represented by the assemblage with the *Eponides*-*Cancris*-*Cibicides*-*Globigerina*-*Globorotalia* fauna, but deeper than environment represented by the mainly "arenaceous" assemblage with *Textularia panamensis*-*Textularia pozonensis*-*Trochammina* spp.

It is because of this repetition of faunal assemblages that no clear distinction can be made between the *Robulus senni* Zone and the *Vaginulinopsis superbus*-*Trochammina* cf. *pacifica* Zone in the Pozón-El Mene Road section.

A further point concerning the composition of the faunas throughout the upper Tocuyo and Pozón formations which needs clarification is the proportion of planktonic specimens to benthonic specimens present in each of the zones. Renz (1948) analysed the faunal composition of each of his zones by calculating the percentage of each foraminiferal family in the assemblage. This method of analysis depends on the number of species recognized in each genus belonging to the family and, since Renz recognized only a few planktonic species, the Orbulinidae and Globorotaliidae were, in general, underestimated.

The writer made a count of the number of planktonic and benthonic specimens occurring in representative samples from each zone. The results of this count and Renz's percentages of planktonic families are compared in the following table (Table 1):—

Table 1

Zone	% of Planktonic Families (Renz, 1948)	Count of Planktonic Specimens	Count of Benthonic Specimens	Ratio P:B (Approx.)	Approx. % of Planktonic Specimens in Fauna
<i>Robulus wallacei</i> Zone	1.5%	923	417	11:5	70%
<i>Siphogenerina transversa</i> Zone	1.5% 2.3% 3.8%	957	278	7:2	78%
<i>Globorotalia fohsi</i> Zone (of Renz, 1948)	2.0% 3.9% 5.9%	1117	421	3:1	75%
<i>Valculineria herricki</i> Zone	1.9% 3.8% 5.7%	959	306	3:1	75%
<i>Margulinopsis basispinosus</i> Zone	2.6% 5.3% 7.9%	729	276	13:5	72%
<i>Textularia panamensis</i> Zone	16.7%	53	209	1:4	20%

Note: Globigerinidae of Renz, 1948 = Orbulinidae of this work.

Stainforth (1948a, p. 1320) made counts of planktonic and benthonic specimens for the Cipero formation of southern Trinidad and gave the following results:—

Zone II (*Globigerinatella insueta* Zone)

2,197 pelagic to 37 benthonic specimens (59:1).

Zone III (*Globorotalia fohsi* Zone)

2,984 pelagic to 119 benthonic specimens (25:1).

Stainforth (1948a, p. 1323) also gave the following percentages (no. of species and varieties as percentages of the Cipero fauna)

Globigerinidae 4.7% (= Orbulinidae of this work)

Globorotaliidae 1.6%

but pointed out that these two families form more than 90% of the fauna in number of specimens within the Cipero formation.

Although the Cipero and Tocuyo/Pozón formations cannot be considered as having been deposited under similar conditions, the figures summarized above show that planktonic specimens are present both in sufficient numbers and variety in the sediments of the Tocuyo and Pozón formations to enable a correlation with the Cipero and Lengua formations of southern Trinidad to be made.

#### IV. CORRELATION OF THE UPPER TOCUYO AND POZÓN FORMATIONS (EASTERN FALCÓN) WITH THE SOUTHERN TRINIDAD SUCCESSION

Cushman and Stainforth (1945), Stainforth (1948a), Bronnimann (1951), Suter (1951), Kugler (1953, 1954), Bolli (1950, 1951, 1957), and Higgins (1955), amongst other authors, have discussed various aspects of the stratigraphy of the post-Eocene deposits in southern Trinidad. The results of their studies is given in a generalized and diagrammatic form on the left-hand side of Chart 1 for sediments above the level of the *Catapsydrax dissimilis* Zone. The right-hand side of this same chart shows the lithostratigraphy and benthonic biostratigraphy of H. H. Renz (1948) together with the planktonic biostratigraphy for the upper part of the Tocuyo and Pozón formations. The correlation between the two areas can be regarded as being firmly established, for the sediments of the two areas, between the *Catapsydrax stainforthi* Zone and the top of the *Globorotalia mayeri* Zone (*s.l.*).

The Tocuyo and Pozón formations appear to have been deposited under conditions of lower tectonic intensity as compared with the depositional conditions which seem to have operated in the area of southern Trinidad at this time. Both Kugler (1953) and Bolli (1957) refer to evidence within the upper Cipero formation and Lengua formation which suggests that penecontemporaneous large-scale slumping and turbidity flows occurred during the deposition of these formations, indicating tectonic movements of high intensity. These features, which relate to an environment of high tectonic intensity, appear to be absent in the Tocuyo and Pozón formations. The lithofacies and biofacies of these latter formations suggest deposition over a continental shelflike area which was, in general, fairly stable.

Because the Tocuyo and Pozón formations were deposited under fairly stable conditions and have subsequently not been much disturbed by post-depositional tectonics, it has been possible to add some further refinements to the planktonic biostratigraphy proposed by Bolli (1957) for southern Trinidad. Furthermore, whereas in southern Trinidad the mainly planktonic foraminiferal faunas of the Lengua formation are replaced upwards by the mainly agglutinated foraminiferal faunas of the Cruse and Forest formations, in eastern Falcón and the Pozón formation continues with an abundant planktonic component to a much higher stratigraphical level. This has led to the necessity of redefining the *Globorotalia menardii menardii* Zone as used by Bolli (1957) and earlier workers. In southern Trinidad, the upper limit of the *Globorotalia menardii menardii* Zone has been taken at the change of biofacies to mainly agglutinated faunas. It has long been recognized by workers in Trinidad that the upper surface of this *Globorotalia menardii menardii* Zone is diachronous since there is known to be an interdigitation and transition between the Lengua formation and the lower part of the overlying Cruse formation. Because of these factors, the writer uses the partial occurrence of *Globigerina nepenthes* Todd above the extinction of *Globorotalia mayeri* Cushman and Ellisor to define a new interval, part of which is equivalent to the *Globorotalia menardii menardii* Zone of southern Trinidad. However, because of the well-established usage of the term "*Globorotalia*

*menardii menardii*" the zone is designated the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone. It is worthy of note that the Lengua/lower Cruse transition beds (Bolli, 1951; Kugler, 1953) also contain *Globigerina nepenthes* (Bolli, 1957). The writer has also observed this species in occasional "streaks" of calcareous faunas seen in subsurface sections of the middle to upper Cruse formation in the Barrackpore area of southern Trinidad, but has not observed *Globigerina nepenthes* in some calcareous faunas associated with the lower Forest Clay (Guapo beds—Suter, 1951 = base of the Forest formation, southern Trinidad). Hence, it is tentatively suggested that the major part of the Cruse formation lies within the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone as defined from the Pozón formation. The writer has observed *Sphaeroidinella seminulina seminulina* (Schwager) in the calcareous facies of the lower Forest Clay of southern Trinidad and it seems likely that part, at least, of the Forest formation can be correlated with the interval ascribed to the *Sphaeroidinella seminulina* Zone as defined in the Pozón formation.

It is emphasized, however, that a correlation between southern Trinidad and eastern Falcón, above the level of the Lengua formation, must still remain tentative owing to the lack of adequate planktonic faunas in the Cruse and Forest formations.

Below the top of the *Globorotalia mayeri* Zone (*s.l.*) the correlation between the two areas may be regarded as well established, although the subdivision of the *Globorotalia mayeri* Zone (*s.l.*) has not been recognized in Trinidad. It appears likely that a large part of the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone is missing in southern Trinidad, although it is noteworthy that Bolli (1957, fig. 18), showed *Globigerina nepenthes* as first appearing slightly above the base of his *Globorotalia mayeri* Zone in the Lengua formation. The *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone may however be represented either in the mainly non-planktonic foraminiferal assemblages of the Karamat formation, or by the heterogenous assemblages of the Río Claro Boulder bed (Suter, 1951; Kugler, 1953). An unconformity or disconformity is known to be present between the Cipero and Lengua formations in some areas of southern Trinidad (Kugler, 1953).

Bolli (1957, p.101) pointed out that the previous study of the present writer (Blow, 1956) regarding the first occurrence of *Globigerinoides bispherica* within the *Globigerinatella insueta* Zone (*s.l.*) would permit a further subdivision of this zone. This subdivision is formally proposed in the present work and two subzones are proposed within the *Globigerinatella insueta* Zone (*s.l.*) in eastern Falcón. As Bolli (1957) implied, the *Globigerinatella insueta*, *Globigerinoides triloba* Subzone and *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone can be recognized in southern Trinidad.

#### V. TENTATIVE CORRELATION OF THE LOWER TOCUYO AND GUACHARACA FORMATIONS (EASTERN FALCÓN) WITH THE SOUTHERN TRINIDAD SUCCESSION

Although this work is based essentially on the samples collected by R. Muhlemann from the Pozón-El Mene Road traverse, and the main object of the study has been to achieve a correlation of the upper part of the Tocuyo formation and the Pozón formation with their equivalent sediments in southern Trinidad, other samples from the subsurface sections of Pozón Well No. 3 and El Mene Wells No. 7 and 47 (see Map 3) were also studied. These subsurface sections penetrate the lower part of the Tocuyo formation and most of the Guacharaca formation.

It appears that the upper part of the "*Uvigerinella*" *sparsicostata* Zone belonging to the lower part of the Tocuyo formation (Renz, 1948, p.30) can be correlated with the basal part of the *Catapsydrax stainforthi* Zone and the *Catapsydrax dissimilis* Zone. The lower part of the "*Uvigerinella*" *sparsicostata* Zone belonging to the upper part of the Guacharaca formation probably correlates with the *Globorotalia kugleri* Zone (Bolli, 1957). Finally, the middle and lower parts of the Guacharaca formation appear to be equivalent to the *Globigerina ciperoensis ciperoensis* Zone, *Globorotalia opima opima* Zone and the *Globigerina ampliapertura* Zone as established by Bolli for the lower part of the Cipero formation of southern Trinidad (see Chart 4).

CHART 4. Provisional Correlation of the lower Part of the Tocuyo and Guacharaca Formations.

AGE	PLANKTONIC BIOZONES (Bolli 1957) (As established for the L.Cipero Formation)	FORMATIONS E. FALCÓN	
MIOCENE (AQUITANIAN)	<i>Catapsydrax dissinilis</i> Zone	<i>"Eugertmella" sparsicostata</i> Zone	SAN LORENZO FORMATION
	<i>Globorotalia kugleri</i> Zone		
— ? —	<i>Globigerina ciperoensis ciperoensis</i> Zone	— ? —	GUACHARACA FORMATION
OLIGOCENE	<i>Globorotalia opima opima</i> Zone		
	<i>Globigerina ampliapertura</i> Zone		
Eocene		CERRO MISIÓN	

Tocuyo should be substituted for San Lorenzo formation

## VI. AGE OF THE GUACHARACA, TOCUYO, AND POZÓN FORMATIONS

Renz (1948, pp. 50-55) considered his *Siphogenerina transversa* Zone to extend from the upper Chattian to the lower Aquitanian. Both these stages were ascribed to the upper Oligocene so that the boundary between the Tocuyo and Pozón formations was considered to occur within the upper Oligocene. Recent work by Eames (1953), Drooger (1956), Eames and Clarke (1957), and the present writer (Blow, 1957) has shown that the ages ascribed by Renz need some modification.

Eames and Clarke (1957) and Blow (1957) have pointed out that *Orbulina* appears for the first time in the uppermost Aquitanian in various parts of the world including the East African and Mediterranean regions, whilst the first occurrence of this form has also been shown to occur in the upper part of the *Globigerinatella insueta*/*Globigerinoides bisphérica* Subzone in both southern Trinidad and eastern Falcón (Blow, 1956). Blow (1957) also pointed out that the planktonic faunas seen in the Aquitanian and Burdigalian of Sicily and Malta can be matched in Trinidad and Venezuela and he has correlated the Burdigalian/Aquitanian boundary as seen in Sicily and Malta with the boundary between the *Globorotalia fohsi barisanensis* Zone and the *Globigerinatella insueta* Zone (*s.l.*) of the Caribbean region. Blow (1957) also reviewed evidence given by Ruscelli (1956) from the Rio Mainia section in Italy and tentatively correlated the Helvetian/Burdigalian boundary with the boundary between the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and the *Globorotalia mayeri* Zone (*s.l.*). This correlation was based essentially on the record by Ruscelli of *Globorotalia mayeri* in the Burdigalian and its absence in the Helvetian of the Rio Mainia section.

However, Ruscelli (1953, p.165) recorded *Globorotalia mayeri* Cushman and Ellisor in the Helvetian of Rio Mazzapiedi-Castellania in Italy where it occurs with *Globorotalia menardii menardii*. The writer also notes that Ruscelli (1956) did not record this latter species from the Burdigalian of the Rio Mainia, and he, therefore,

now tentatively places the Helvetian/Burdigalian boundary at the top of the *Globorotalia fohsi robusta* Zone in the Caribbean (see Chart 1), since *Globorotalia menardii menardii* (d'Orbigny) first appears only in the upper part of this interval.

The writer has not observed *Globorotalia mayeri* in the Tortonian of Sicily, but has observed *Globorotalia acostaensis* Blow sp. nov. commonly in this interval. Since *Globorotalia acostaensis* shows some resemblance to *Globorotalia mayeri*, it is possible that records of the latter species in the Tortonian (i.e., Giannotti, 1953) may be incorrect and possibly referable to *Globorotalia acostaensis*.

The writer now points out that the origin and first occurrence of *Globorotalia acostaensis* is above the extinction of *Globorotalia mayeri*, in sediments now regarded by the writer as being equivalent to the Vindobonian.

Furthermore, *Globigerina bulloides* d'Orbigny, as distinct from *Globigerina praebulloides* Blow, sp. nov., has only been seen in Tortonian strata in Sicily, not in earlier Miocene stages. In this study it is also pointed out that *Globigerina bulloides* develops from *Globigerina praebulloides* in the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone in eastern Falcón. Again the writer has observed *Sphaeroidinella seminulina seminulina* (Schwager) and *Sphaeroidinella dehiscens subdehiscens* Blow, subsp. nov. in the Tortonian of Sicily, but has not observed *Globigerina nepenthes* Todd in this interval.

Finally, Blow (1957) pointed out that *Globigerina ciperoensis ciperoensis* Bolli has been found in Sicily within the lower part of the Aquitanian as defined by the occurrence together of *Miogypsina globulina* (Michelotti) (= *Miogypsina irregularis* (Michelotti)—an invalid name, (fide Dr. F. E. Eames) and *Miogypsinella* [*Miogypsinoides*] *complanata* (Schlumberger), and he regarded at least part of the *Globigerina ciperoensis ciperoensis* Zone of the Caribbean as belonging to the Aquitanian which, in agreement with Eames (1953), is here considered to be lower Miocene.

Hence, based on the conclusions of Eames and Clarke (1957) and the writer's studies, it is considered that the Guacharaca formation should be regarded as Oligocene with some lower Aquitanian (basal Miocene) in its upper part. The Tocuyo formation comes a

little higher in the Aquitanian, and the Pozón formation extends from uppermost Aquitanian throughout the Burdigalian into the Vindobonian (see Charts 1 and 4).

## VII. EVOLUTION OF SOME OLIGOCENE AND MIOCENE GLOBOROTALIIDAE AND ORBULINIDAE

Following the extinction of the characteristic, and often morphologically complex, Eocene planktonic Foraminifera, such as *Hantkenina*, *Truncorotaloides*, *Globigerinatheka barri* Bronnimann, and *Porticulasphaera mexicana* (Cushman), there is a considerable reduction in the number of species belonging to the Orbulinidae and Globorotaliidae. Only a few species of these families persists from the upper Eocene to the lower Oligocene. With the exception of *Catapsydrax*, these lower Oligocene forms are of comparatively simple morphology.

The reduction in planktonic foraminiferal species at the Eocene-Oligocene boundary is only surpassed in intensity by the almost complete break at the Cretaceous-Tertiary boundary. In a similar way to the primitive lower Paleocene *Globigerina* and *Globorotalia* fauna, it is found that the lower Oligocene planktonic foraminiferal fauna rapidly begins to expand again into numerous new species and genera. The cause of such catastrophic reductions of certain faunal groups may possibly have been occasioned by comparatively minor, although world-wide, changes in environmental condition, such as a sudden lowering of mean sea temperature.

The most remarkable reduction in number of species at the end of the Eocene occurs within the Globorotaliidae. In the Caribbean area, it appears that only one species of *Globorotalia* persists in the lower Oligocene, i.e., *Globorotalia opima* Bolli. This species appears to be the ancestor of the lineage shown on Text-Figure 1 (Lineage I). In the lower Aquitanian (*Catapsydrax dissimilis* Zone), *Globorotalia scitula praescitula* Blow is first observed and this form is believed to be the ancestor of the lineage shown on Text-Figure 2 (Lineage II). However, the origin of *Globorotalia scitula praescitula* itself, and the origins of some other uppermost Oligocene or lowermost Miocene species of *Globorotalia*, such as

*Globorotalia obesa* Bolli and *Globorotalia kugleri* Bolli, are still not clear.

Amongst the apparently unspecialized *Globigerina* species which exist either in upper Oligocene or lowermost Miocene times are *Globigerina praebuloides* Blow, *Globigerina juvenilis* Bolli, and *Globigerina* cf. *trilocularis* d'Orbigny (of Bolli, 1957), these forms seem to be the respective ancestors of the lineages shown on Text-Figures 3, 4 and 5 (Lineages III, IV and V).

In the discussion of the lineages below, only the main features of the evolutionary series are noted; further details are given in the appropriate parts of the "Systematic Record" where some other possible evolutionary inter-relationships are noted in addition.

#### LINEAGE I (See Text-Fig. 1)

Three branches of this lineage are distinguished:—

- (i) *Globorotalia opima* (s.l.) → *Globorotalia acostaensis*,  
Branch
- (ii) *Globorotalia opima* (s.l.) → *Globorotalia mayeri*,  
Branch
- (iii) *Globorotalia mayeri* → *Globorotalia fohsi* (s.l.),  
Branch

*Branch (i).*—*Globorotalia opima nana* Bolli is a small form with four to five chambers in the last whorl; they are spherical in shape inflated, and rather embracing. *Globorotalia opima opima* Bolli developed first as a short-lived independent off-shoot from *Globorotalia opima nana*; the evolution to *Globorotalia opima opima* being characterized by a considerable increase in size of the test and the coiling becoming slightly tighter.

*Globorotalia opima continuosa* Blow develops from *Globorotalia opima nana* Bolli in the basal part of the *Catapsydrax stainforthi* Zone. The two forms are closely related but *Globorotalia opima continuosa* differs from *Globorotalia opima nana* in having a more strongly arched aperture with a more distinctive lip, and also in having ovate or subspherical chambers as compared with the spherical chambers of *Globorotalia opima nana*. The



test of "*continua*" remains thick but tends to become parallel-sided. *Globorotalia acostaensis* Blow develops from *Globorotalia opima continua* in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone after the extinction of *Globorotalia mayeri* Cushman and Ellisor. The evolution of *Globorotalia acostaensis* from *Globorotalia opima continua* is characterized by an increase in size of the test which remains thick or even becomes relatively thicker; the number of chambers in the last whorl increases, and the chambers become much inflated and broad. Further, the apertural lip of *Globorotalia acostaensis* is usually even more well developed than it is in *Globorotalia opima continua*.

*Branch (ii).*—The evolution of *Globorotalia mayeri* Cushman and Ellisor from *Globorotalia opima nana* Bolli is characterized by an increase in size of the test which becomes relatively thinner; the number of chambers in the last whorl also increases, the chambers becoming less inflated and narrow. The apertural lip of *Globorotalia mayeri* is not strongly developed.

Although the same general evolutionary trends prevailed in the evolution of *Globorotalia mayeri* and *Globorotalia acostaensis*, there are considerable differences of detail especially in regard to chamber shape and relative dimensions of the test. Furthermore, the trends operated at two distinctly different intervals of time.

*Branch (iii).*—Bolli (1957, p.118) suggested that *Globorotalia fohsi barisanensis* (LeRoy) might have developed from *Globorotalia mayeri* Cushman and Ellisor in the *Catapsydrax dissimilis* Zone. The present writer regards this origin for *Globorotalia fohsi barisanensis* as being most likely. The derivation of *Globorotalia fohsi barisanensis* from *Globorotalia mayeri* involves the chambers becoming more tangentially elongate and the sutures of the spiral side becoming more strongly curved. The subsequent evolution of the *Globorotalia fohsi* group, with the gradual attainment of an acute periphery which in turn becomes keeled, has been discussed by Bolli (1950).

## LINEAGE II (see Text-Fig. 2)

Three branches of this lineage are distinguished:—



- (i) *Globorotalia scitula* (s.l.) → *Globorotalia* cf. *canariensis*,  
Branch
- (ii) *Globorotalia scitula praescitula* → *Globorotalia menardii*  
(s.l.), Branch
- (iii) *Globorotalia scitula praescitula* → *Globorotalia minima* →  
→ *Globorotalia linguaensis*, Branch

*Branch (i).*—*Globorotalia scitula praescitula* Blow has rather elongate chambers as seen from the spiral side and a subacute axial periphery, as well as a distinctly convex to rather vaulted umbilical side. *Globorotalia scitula scitula* (Brady) develops from “*praescitula*” by the gradual attainment of a more equally biconvex test and a less lobate equatorial periphery; also, the chambers become almost hemispherical as seen from the spiral side and relatively less elongate tangentially as compared with their breadth. *Globorotalia scitula gigantea* Blow develops in turn from *Globorotalia scitula scitula* (Brady), mainly by a considerable increase in test size and by the test becoming virtually equally biconvex.

Forms which are referred to in this study as *Globorotalia* cf. *canariensis* (d'Orbigny) appear to develop from *Globorotalia scitula scitula* (Brady) by the development of a thin but distinctive keel and by the test becoming more compressed.

*Branch (ii).*—*Globorotalia menardii archeomenardii* (Bolli) appears to develop from *Globorotalia scitula praescitula* Blow by the attainment of rather angular rhomboidal-shaped chambers as seen from the side view. The periphery gradually becomes increasingly acute and ineventually a thin keel appears on the last few chambers, this keel subsequently extending throughout the whole test. *Globorotalia menardii praemenardii* (Cushman and Stainforth) developed from “*archeomenardii*” by the attainment of a more lobate equatorial periphery and more chambers as well as a more rapidly opening spire. *Globorotalia menardii menardii* (d'Orbigny) developed from “*praemenardii*” by the gradual development of raised sutures on the spiral side and a much more massive keel. *Globorotalia menardii miocenica* Palmer evolved from *Globorotalia menardii menardii* by the development of a strongly vaulted umbilical side and a flat spiral side.

*Branch (iii).*—*Globorotalia minima* (Akers) appears to develop from *Globorotalia scitula praescitula* Blow by the adoption of a less lobate equatorial periphery and the acquisition of more chambers in the last whorl. The last two chambers remain elongate tangentially, but the early chambers become almost equally as broad as long. *Globorotalia linguaensis* Bolli is considered to have developed from *Globorotalia minima* by the adoption of a more circular equatorial profile with the spire opening less rapidly so that all the chambers are almost equally as broad as long. The axial periphery becomes subacute to acute and a faint keel may develop on some or all of the chambers in specimens of *Globorotalia linguaensis* from stratigraphically higher horizons.

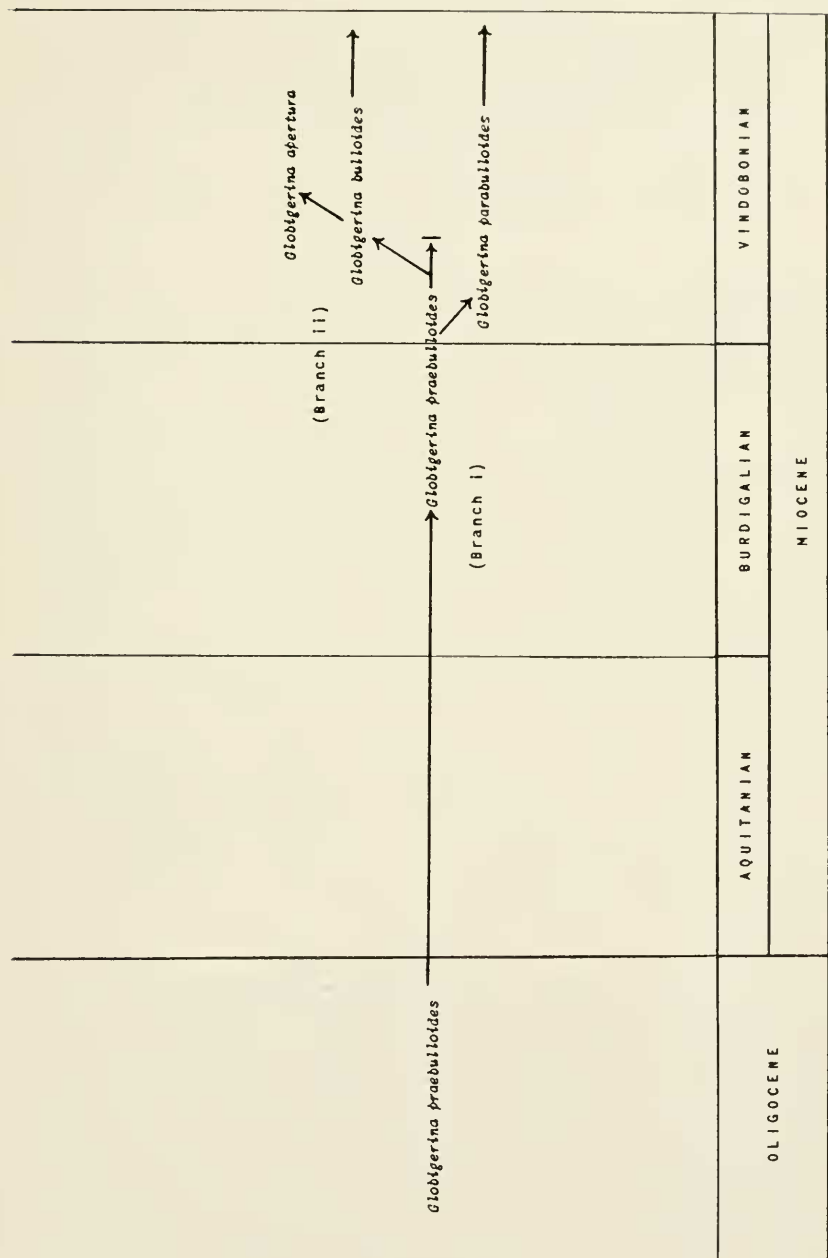
### LINEAGE III (see Text-Fig. 3)

Two branches of this lineage are distinguished:—

- (i) *Globigerina praebulloides* → *Globigerina parabolloides*,  
Branch
- (ii) *Globigerina praebulloides* → *Globigerina bulloides* →  
→ *Globigerina apertura*, Branch

*Branch (i).*—*Globigerina praebulloides* Blow has a weakly trochospiral test with four to five chambers in the last whorl. The chambers are appressed, slightly embracing, and increase fairly rapidly in size as added, so that the equatorial profile is ovate. The aperture is not strongly arched and is without a lip or distinctly thickened rim. *Globigerina parabolloides* Blow developed from “*praebulloides*” by the adoption of a smaller aperture which possesses a distinct lip or thickened rim. The equatorial profile remains distinctly elongate in the direction of the last chamber.

*Branch (ii).*—*Globigerina bulloides* d'Orbigny developed from *Globigerina praebulloides* by the adoption of a more highly arched aperture, a more strongly trochospiral test, a deeper umbilicus, and chambers which increase regularly but not rapidly in size as added, so that the equatorial profile is subcircular. *Globigerina apertura* Cushman developed from *Globigerina bulloides* by the coiling becoming looser so that the umbilicus becomes wider, and also by the aperture becoming highly arched with a distinct thickened rim.



Text-Figure 3. Lineage III. (Not strictly to scale.)

## LINEAGE IV (see Text-Fig. 4)

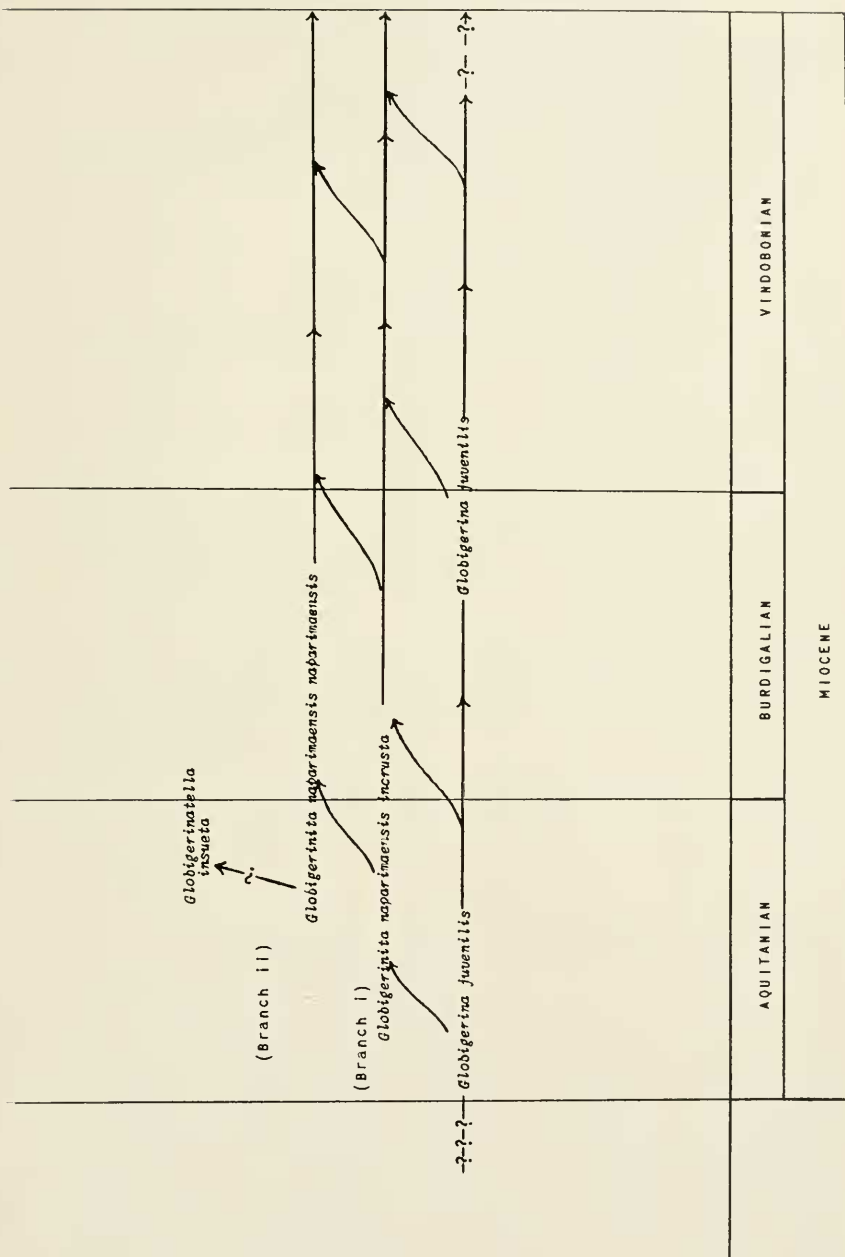
Two branches are distinguished within this lineage:—

- (i) *Globigerina juvenilis* → *Globigerinita naparimaensis* (s.l.),  
Branch
- (ii) *Globigerinita naparimaensis* (s.l.), → ? → *Globigerinatella*  
*insueta*, Branch

*Branch (i).*—*Globigerina juvenilis* Bolli has three to four inflated chambers in the last whorl and the narrow, elongate and slit-like aperture possesses a distinctive lip. *Globigerinita naparimaensis incrusta* (Akers) appears to have developed from *Globigerina juvenilis* by the apertural lip of this latter form becoming attached to the ventral surface of the opposing chamber and forming a bulla which, however, only has infralaminar apertures in line with the sutures of the primary chambers. *Globigerinita naparimaensis naparimaensis* Bronnimann developed from “*incrusta*” by the bulla becoming more inflated and embracing more of the primary chambers, and also by the adoption of infralaminar apertures in the suture between the bulla and the primary chambers; it also retains the infralaminar apertures in line with the sutures between the primary chambers. It is considered possible that the evolution

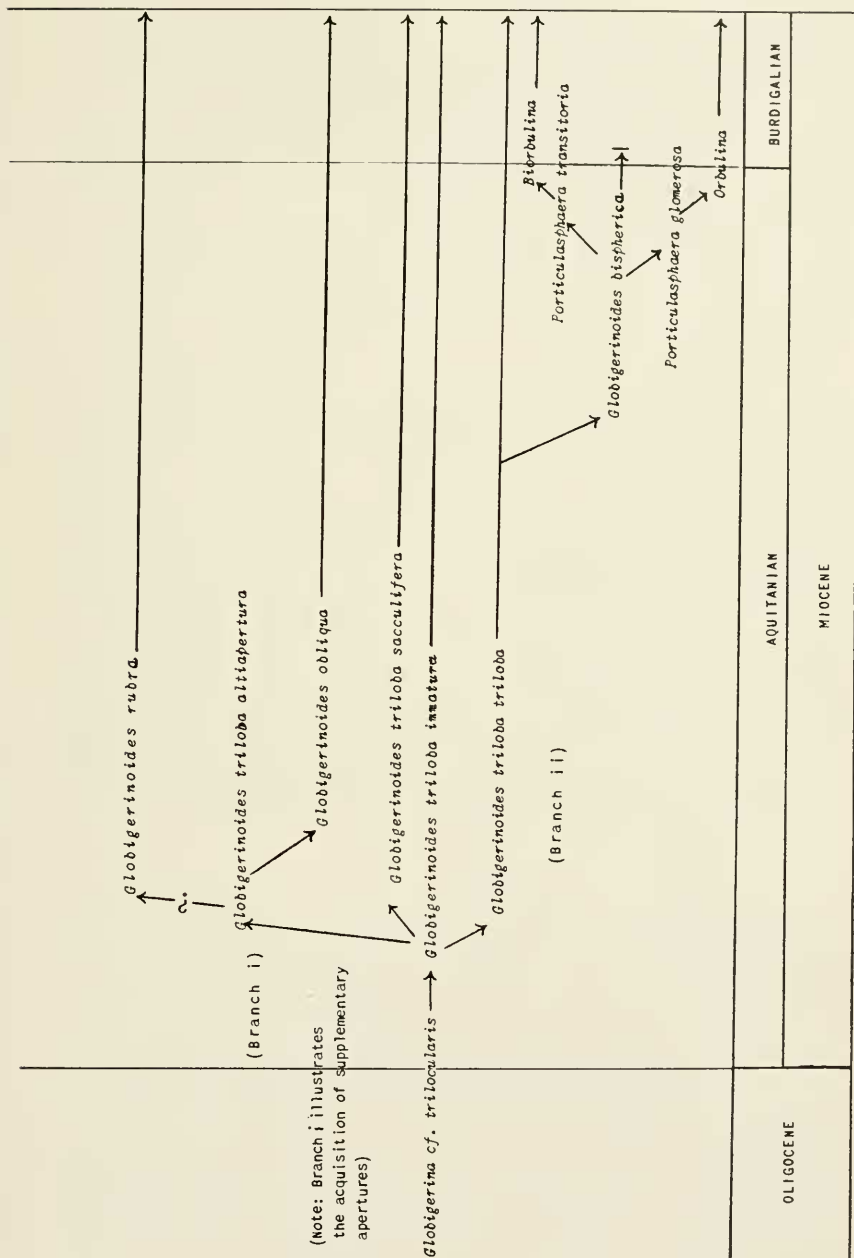
*Globigerina juvenilis* → *Globigerinita naparimaensis incrusta* →  
→ *Globigerinita naparimaensis naparimaensis*  
may have occurred a number of times throughout the Miocene in a repetitive and heterochronous manner. Further details of this possible repetitive evolution are discussed in the “Systematic Record.”

*Branch (ii).*—It seems likely that *Globigerinatella insueta* Cushman and Stainforth developed from *Globigerinita naparimaensis naparimaensis* Bronnimann. Some early forms of *Globigerinatella insueta* show only a single “primary” bulla without “secondary” bullae, either in the form of areal pustules or collar-like growths, although the primary chambers are embracing. Dissection of these early forms also shows that there are multiple apertures in the primary chambers, so that there is no longer one single primary aperture as seen in *Globigerinita*, but supplementary sutural and areal apertures as well. It is believed that the following trends have



Text-figure 4. Lineage IV. (Not strictly to scale)





Text-Figure 5. Lineage V. (Not strictly to scale.)

LeRoy's form possesses supplementary sutural apertures. A similar relationship has also been seen in the *Globorotalia kugleri* Zone of eastern Falcón. In the early forms of *Globigerinoides triloba immatura*, supplementary apertures are only present in the suture between the last and penultimate chambers, but in specimens from stratigraphically higher horizons supplementary apertures appear in the sutures between the penultimate and earlier chambers. The apertures of *Globigerinoides triloba immatura* are only slightly arched, and this form has a last chamber which only slightly embraces the earlier part of the test; the last chamber is slightly smaller in volume than the rest of the earlier chambers combined.

*Globigerinoides triloba sacculifera* (Brady) developed from *Globigerinoides triloba immatura* by the production of an elongate, saclike last chamber which has a slightly higher arched primary aperture.

*Globigerinoides triloba altiapertura* Bolli appears also to have developed from *Globigerinoides triloba immatura* by the adoption of rounded and highly arched primary and supplementary apertures; also by the chambers becoming slightly more inflated and better separated one from the other. *Globigerinoides obliqua* Bolli is considered to have developed from *Globigerinoides triloba altiapertura* in the basal part of the *Catapsydrax dissimilis* Zone by developing an elongate aperture which, however, remains fairly highly arched; the early chambers remain spherical, but later chambers become laterally compressed in an oblique manner.

*Globigerinoides rubra* (d'Orbigny) is considered possibly to have originated from *Globigerinoides triloba altiapertura* by the reduction of the number of chambers in the last whorl to 3 from the usual  $3\frac{1}{2}$  to 4 which are present in the last whorl of *Globigerinoides triloba altiapertura*. At the same time, the primary and supplementary apertures become symmetrically placed with respect to the suture between the earlier chambers. Later forms of *Globigerinoides rubra* show a tendency to become rather high-spined.

*Branch (ii).*—*Globigerinoides triloba triloba* (Reuss) developed from *Globigerinoides triloba immatura* LeRoy by the last chamber gradually embracing more of the earlier test and by the primary and supplementary apertures becoming completely slitlike

and more elongate as compared with the slightly arched apertures of "*immatura*". Blow (1956) discussed the evolution of *Globigerinoides bispherica* Todd from *Globigerinoides triloba triloba*, and also the evolution of *Biorbulina* and *Orbulina* from Todd's species via *Porticulasphaera transitoria* and *Porticulasphaera glomerosa*, respectively.

## VIII. SOME NOTES ON THE TAXONOMY OF THE FORAMINIFERA

### (a) Benthonic Foraminifera.

Although the present biostratigraphical studies made by the writer for the Tocuyo and Pozón formations have been largely concerned with the stratigraphical distribution of planktonic Foraminifera, it was found to be necessary to analyse the benthonic foraminiferal content of each sample in the section so as to arrive at a direct correlation between the two types of foraminiferal biostratigraphies.

During this study the opportunity has been taken to examine and, where necessary, revise the taxonomy of the benthonic fauna as proposed by H. H. Renz in 1948. In general, Renz's taxonomy has been maintained with few exceptions. The most important changes are listed below whilst some other minor changes are noted in the relevant parts of the "Systematic Record":—

Blow	Renz (1948)
<i>Alveovalvulinella</i>	<i>Liebusella pozonensis</i>
<i>pozonensis</i>	
<i>Alveolophragmium?</i>	<i>Haplophragmoides carinatum</i>
<i>carinatum</i>	
<i>Alveolophragmium</i>	<i>Haplophragmoides emaciatum</i>
<i>venezuelanum</i>	
<i>Bolivina pseudobeyrichi</i>	<i>Bolivina alata</i>
<i>Glandulina laevigata</i>	<i>Pseudoglandulina laevigata</i>
<i>Gyroidinoides altiformis</i>	<i>Gyroidinoides soldanii altiformis</i>
<i>Gyroidinoides</i> cf. <i>zealandica</i>	<i>Gyroidinoides</i> cf. <i>soldanii</i>
<i>Nodosaria caribbeana</i>	<i>Nodosaria raphanistrum caribbeana</i>

<i>Nodosaria comatus</i>	<i>Pseudoglandulina comatula</i>
<i>Pseudonodosaria incisa</i>	<i>Pseudoglandulina incisa</i>
<i>Rectoglandulina gallowayi paucicostata</i>	<i>Pseudoglandulina gallowayi paucicostata</i>
<i>Stilostomella verneuili</i>	<i>Ellipsonodosaria? verneuili</i>
<i>Vaginulina sublituus</i>	<i>Astacolus sublituus</i>

In addition to these changes, the following benthonic Foraminifera were observed in the Pozón-El Mene Road section but were not mentioned by Renz in 1948:—

- Ammodiscus muhlemani* Blow, sp. nov.
- Gravellina narivaensis* Bronnimann
- Lagena asperoides* Galloway and Morrey
- Lagena nuttalli* Galloway and Heminway
- Lagenonodosaria acostaensis* Blow, sp. nov.
- Uvigerina cubana* Palmer and Bermudez

The stratigraphical distribution of the benthonic Foraminifera observed in the Pozón-El Mene Road section is given on Chart 2.

#### (b) *Planktonic Foraminifera*

Recently, Bolli, Loeblich, and Tappan (1957) made a detailed revision of the taxonomy of the planktonic Foraminifera. With one minor exception, their recommendations are followed in this work. These authors also made recommendations as to the terminology used in the description of the morphology of the planktonic forms. These recommendations are also closely followed.

### SYSTEMATIC RECORD

All holotypes, paratypes, and hypotypes, as well as any other figured specimens, have been deposited in the collections of the United States National Museum, Washington, D.C., U.S.A.

The classification followed in this Systematic Record is based upon that proposed by Cushman (1950) but with some modifications due to recent work by various authors. The main changes affect the classification of the planktonic Foraminifera where the recommendations of Bolli, Loeblich, and Tappan (1957) are followed with the exception of the taxonomic position of the genus *Hastigerinella*. *Hastigerinella* is, in this work, placed in the family Globorotaliidae.

Phylum **PROTOZOA**Order **FORAMINIFERA**Family **AMMODISCIDAE**Genus **AMMODISCUS** Reuss, 1861***Ammodiscus incertus*** (d'Orbigny)

*Operculina incerta* d'Orbigny, 1839, "Foraminifères", in de la Sagra, Histoire physique, politique et naturelle de l'île Cuba, p. 49, pl. 6, figs. 16, 17 (*vide* Ellis and Messina, 1940 *et seq.*).

*Ammodiscus incertus* (d'Orbigny), (Cushman), 1918, U.S. Nat. Mus., Bull. 104, pt. 1, p. 95, pl. 39, figs. 1-8.

*Remarks*:—Species shows wide variation, partly due to the type of material incorporated in the test; spiral suture usually distinct and the second chamber rounded in cross-section.

*Hypotype*:—From Sample No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625734.

*Occurrence*:—Occurs mainly in arenaceous facies faunas of the *Globigerinatella insueta* Zone (*s.l.*) but also as isolated specimens in the *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations.

***Ammodiscus mublemanni*** Blow, sp. nov.

Pl. 6, figs. 1a-b

*Diagnosis*:—Test small, usually compressed, agglutinated, but with much calcareous cement; proloculum small and indistinct, followed by an undivided or nonconstricted second chamber forming a planispiral coil of about 7 to 10 whorls. The second chamber, which only increases slowly in size, has a rounded cross-section. Spiral suture usually distinct; wall smoothly finished and almost translucent; maximum diameter of holotype, 0.42 mm.

*Remarks*:—This form is usually observed deformed and compressed, but occasional specimens indicate that the cross-section of the second chamber is round. The adventitious material selected is fine-grained, and the form has a characteristic translucent appearance.

*Holotype*:—From Sample No. RM 19180, auger line near Pozón, eastern Falcón; Plate 6, figs. 1a-b, deposited in U.S.N.M. collection, No. 625691.

*Occurrence*:—This form seems to be restricted to mainly “arenaceous facies faunas” of the *Globigerinatella insueta* Zone (*s.l.*) Tucuyo and Pozón formations. Also observed in the Nariva formation of southern Trinidad.

Genus **GLOMOSPIRA** Rzehak, 1888

**Glomospira gordialis** (Jones and Parker)

*Glomospira gordialis* (Jones and Parker), Cushman, 1928, Cushman Lab. Foram. Res., Contr., vol. 4, p. 87, figs. 7-8.

*Hypotype*:—From Sample, No. RM 19283, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625736.

*Occurrence*:—Scarce, observed in the *Globigerinatella insueta* Zone (*s.l.*); also infrequently in samples from the *Globorotalia fohsi* “Zone” (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations.

Family **LITUOLIDAE**

Genus **ALVEOLOPHRAGMIUM** Stschedrina, 1936

**Alveolophragmium?** *carinatum* (Cushman and Renz)

*Haplophragmoides carinatum* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 2., pl. 1, fig. 1.

*Remarks*:—*Alveolophragmium?* *carinatum* differs from *Alveolophragmium venezuelanum* Maync in the larger number of chambers and somewhat more compressed test which has a distinctly keeled periphery. The sutures are slightly raised. The specimens observed do not show details of the aperture but appear to have a labyrinthic or alveolar wall structure and are, therefore, referred tentatively to the genus *Alveolophragmium* Stschedrina, 1936. The specimens also appear identical to Cushman and Renz’s species.

*Hypotype*:—From Sample, No. RM 19136, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625737.

*Occurrence*:—Occurs mainly in arenaceous facies faunas from the *Catapsydx stainforthi* Zone, and in the *Globigerinatella insueta* Zone (*s.l.*), but, occasional specimens have been observed in all zones below the base of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

**Alveolophragmium venezuelanum** Maync

Pl. 6, fig. 2

*Nov. Haplophragmium emaciatum* Brady, 1884, Challenger Exped. Rept., Zool., vol. 9, pt. 22, p. 305, pl. 33, figs. 26-28.

*Haplophragmoides emaciatum* Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 142, pl. I, figs. 6a-b.

*Alveolophragmium venezuelanum* Maync, 1952, Cushman Found. Foram. Res., Contr., vol. III, pts. 3 & 4, p. 142, pl. 26, figs. 1-3, 5.

*Remarks:*—Maync (1952) transferred Renz's (1948) species to the genus *Alveolophragmium* Stschedrina and considered this species to be distinct from that described by Brady (1884). The specimens observed by the writer are similar to those illustrated by Renz (1948, p.142) and show clearly the alveolar nature of the test wall.

*Hypotype:*—From Sample, No. RM 19136, auger line near Pozón, eastern Falcón; Plate 6, fig. 2, deposited in U.S.N.M. collection, No. 625739.

*Occurrence:*—Generally scarce throughout the upper part of the Tocuyo formation and in the *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Pozón formation.

Genus **AMMOBACULITES** Cushman, 1910**Ammobaculites cf. strathearnensis** Cushman and LeRoy

cf. *Ammobaculites strathearnensis* Cushman and LeRoy, 1938, Jour. Pal., vol. 12, No. 2, p. 122, pl. 22, figs. 1a, 1b, 2a, 2b (*vide* Ellis and Messina, 1940 *et. seq.*).

*Ammobaculites cf. strathearnensis* Cushman and LeRoy, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 113, pl. 1, figs. 7,8.

*Remarks:*—This species shows a rather wide variation in morphology, especially in the degree to which the last few chambers uncoil and in the depth of the umbilicus. Test compressed; wall structure smooth, composed of fine grains.

*Hypotype:*—From sample, No. RM 19136, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625740.

*Occurrence:*—Occurs rarely, mainly in arenaceous facies faunas from the *Catapsydrax stainforthi* Zone and in the *Globigerinatella insueta* Zone (*s.l.*). Occasional specimens have been observed throughout the *Globorotalia fohsi* Zone (*s.l.*), and possibly in the *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations .

Genus **CYCLAMMINA** Brady, 1876**Cyclammina cancellata** Brady

*Cyclammina cancellata* Brady, 1884, Challenger Exped. Rept., Zool., vol. 9, p. 351, pl. 37, figs. 8-16.

*Remarks:*—Both Glaessner (1945) and Cushman (1950) refer to the labyrinthic interior of this genus. Bronnimann (1951c) suggested that the term "labyrinthic" should not be used in connection with this form and described the interior as being subdivided into regularly arranged alveoles normal to the outer cortex. Maync (1952, p.48), however, retained the term "labyrinthic" and pointed out that the attribute "labyrinthic" should be applied only to the wall and septal structure and not to the complex nature of the actual chambers.

*Hypotype:*—From sample, No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625741.

*Occurrence:*—Occurs in variable abundance in the Tocuyo and Pozón formations below the *Sphaeroidinella seminulina* Zone but particularly common in the *Globigerinatella insueta* (s.l.), where it occurs in arenaceous facies faunas and often associated with comparatively rich, mainly planktonic faunas.

It has been suggested that an abundance of this species indicates a deepwater turbid environment (Kugler, 1953).

Genus **HAPLOPHRAGMOIDES** Cushman, 1910**Haplophragmoides coronatum** (Brady)

*Trochammina coronata* Brady, 1879, Quart. Jour. Micr. Sci., London, vol. 19, p. 58, pl. 5, fig. 15 (*vide* Ellis and Messina, 1940 *et seq.*).

*Remarks:*—This species is always observed much deformed, but appears to be planispirally coiled throughout.

*Hypotype.*—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625743.

*Occurrence:*—Occurs mainly in arenaceous facies faunas from the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta* Zone (s.l.), Tocuyo and Pozón formations.

Family **TEXTULARIIDAE**Genus **TEXTULARIA** DeFrance, 1824**Textularia crassisepta** Cushman

*Textularia crassisepta* Cushman, 1911, U.S. Nat. Mus., Bull. 71, p. 24, text-fig. 41 (*vide* Ellis and Messina, 1940, *et seq.*).

*Hypotype*:—From sample, No. RM 19279, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625744.

*Occurrence*:—Scarce, but observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*) and in the lower to middle part of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

***Textularia excavata* Cushman**

*Textularia excavata* Cushman, 1913, U.S. Nat. Mus., Proc., vol. 44, No. 1973, p. 634, pl. 79, fig. 5 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample No. RM 19279, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625746.

*Occurrence*:—Scarce, only seen in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Textularia isidroensis* Cushman and Renz**

*Textularia isidroensis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 4, pl. 1, fig. 7.

*Hypotype*:—From sample No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625748.

*Occurrence*:—Scarce, only seen in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Textularia leuzingeri* Cushman and Renz**

*Textularia leuzingeri* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 3, pl. 1, fig. 2.

*Hypotype*:—From sample No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection No. 625749.

*Occurrence*:—Scarce, only seen in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Textularia panamensis* Cushman**

Pl. 7, fig. 3

*Textularia panamensis* Cushman, 1918, U.S. Nat. Mus., Bull. 103, p. 63, pl. 20, fig. 1 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample No. 20131, auger line near Pozón, eastern Falcón; Plate 7, fig. 3, deposited in U.S.N.M. collection, No. 625750.

*Occurrence*:—Scarce in the lower part of the *Sphaeroidinella seminulina* Zone but becomes common in the middle to upper part of this zone and in the lower part of the *Globigerina bulloides* Zone, Pozón formation.

**Textularia pozonensis** Cushman and Renz

*Textularia pozonensis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 4, pl. 1, fig. 6.

*Hypotype*:—From sample, No. RM 20131, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625752.

*Occurrence*:—Scarce in the lower part of the *Sphaeroidinella seminulina* Zone but becomes common in the middle to upper part of this zone and in the lower part of the *Globigerina bulloides* Zone, Pozón formation.

Genus **VULVULINA** d'Orbigny, 1826

**Vulvulina spinosa miocenica** Cushman

*Vulvulina spinosa* Cushman var. *miocenica* Cushman, 1932, Cushman Lab. Foram. Res., Contr., vol. 8, p. 80, pl. 10, fig. 10 (*vide* Renz, 1948).

*Vulvulina spinosa* Cushman var. *miocenica* Cushman, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 179, pl. 11, fig. 1.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625753.

*Occurrence*:—Scarce, only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

Family **VERNEUILINIDAE**

Genus **GAUDRYINA** d'Orbigny, 1839

**Gaudryina leuzingeri** Cushman and Renz

*Gaudryina leuzingeri* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 6, fig. 13.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625755.

*Occurrence*:—Scarce, only observed in a few samples from the *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

**Gaudryina thalmani** Cushman and Renz

*Gaudryina thalmani* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 7, fig. 14.

*Hypotype*:—From sample, No. RM 19265, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625756.

*Occurrence*:—Scarce, only observed in a few samples from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, Pozón formation.

Subgenus **PSEUDOGAUDRYINA** Cushman, 1936

**Gaudryina** (*Pseudogaudryina*) *bullbrookii* Cushman

*Gaudryina* (*Pseudogaudryina*) *bullbrookii* Cushman, 1936, Cushman Lab. Foram. Res., Spec. Pub. No. 6, p. 16, pl. 2, fig. 16.

*Hypotype*:—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625758.

*Occurrence*:—Generally scarce and only occurs in isolated samples but ranges from the *Catapsydrax stainforthi* Zone, Tocuyo formation, to the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

**Gaudryina** (*Pseudogaudryina*) *jacksonensis abnormis* Cushman and Renz

*Gaudryina* (*Pseudogaudryina*) *jacksonensis* Cushman var. *abnormis* Cushman and Renz, 1944, Cushman Lab. Foram. Res., Contr., vol. 20, pt. 3, p. 78.

*Gaudryina jacksonensis* Cushman var. *abnormis* Cushman and Renz, Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625760.

*Occurrence*:—Fairly common in the *Catapsydrax stainforthi* Zone but has only been observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

Genus **PSEUDOCLAVULINA** Cushman, 1936

**Pseudoclavulina** *carinata* (Cushman and Renz)

*Clavulina carinata* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 8, pl. 1, fig. 18.

*Remarks*:—This species shows a fairly large triangular initial part with three chambers per whorl followed by 2-3 rounded, uniserial chambers with a circular terminal aperture. The aperture in the adult has a short neck and is without a tooth. The uniserial chambers are comparatively distinct, more so than the initial ones; wall rough.

*Hypotype*:—From sample, No. RM 19286, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625762.

*Occurrence*:—Generally scarce in the Tocuyo and Pozón formations below the middle part of the *Sphaeroidinella seminulina* Zone.

### Family VALVULINIDAE

Genus *ALVEOVALVULINELLA* Bronnimann, 1953

*Alveovalvulinella pozonensis* (Cushman and Renz) Pl. 6, fig. 4

*Liebusella pozonensis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, p. 9, figs. 1, 2.

*Liebusella pozonensis* var. *crassa* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, p. 10, pl. 2, figs. 3-4.

*Alveovalvulinella pozonensis* (Cushman and Renz), Bronnimann, 1953, Cushman Found. Foram. Res., Contr., vol. IV, pt. 3, p. 91, text-figs. IV, V, plate 15, fig. 3.

*Remarks*:—Bronnimann transferred this species from the genus *Liebusella* Cushman, 1933 to a new valvulinid genus *Alveovalvulinella* mainly because of the alveolated, not "labyrinthic", nature of the test wall. The early part of the test consists of more than three chambers in a whorl later reducing to three, then two and eventually becoming uniserial. The uniserial part often comprises most of the test. Wall often appears translucent showing the alveoles. Aperture terminal in uniserial part of the test.

*Hypotype*:—From sample, No. RM 19175, auger line near Pozón, eastern Falcón; Plate 6, fig. 4, deposited in U.S.N.M. collection, No. 625763.

*Occurrence*:—In Trinidad it is diagnostic for, and restricted to, the Nariva clays and silts, whilst in the Pozón section it occurs mainly in arenaceous facies faunas from the *Catapsydrax stain-jorthi* Zone and *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations. It also occurs in isolated samples from the *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

Genus *GRAVELLINA* Bronnimann, 1953

*Gravellina narivaensis* Bronnimann Pl. 6, fig. 5

*Gravellina narivaensis* Bronnimann, 1953, Cushman Found. Foram. Res., Contr., vol. IV, pt. 3, p. 87, pl. 15, fig. 9, text-fig. 1.

*Hypotype*:—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; Plate 6, fig. 5, deposited in U.S.N.M. collection, No. 625765.

*Occurrence*:—Generally scarce and only observed in arenaceous facies faunas from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations. In Trinidad it is considered diagnostic for the Nariva formation.

Genus **SCHENCKIELLA** Thalmann, 1942

**SchenckIELLA** cf. *cyclostomata* (Galloway and Morrey)

cf. *Verneuilina cyclostomata* Galloway and Morrey, 1929, Bull. Amer. Pal., vol. 15, No. 55, p. 33, pl. 5, fig. 2.

*SchenckIELLA* cf. *cyclostomata* (Galloway and Morrey), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 163, pl. II, fig. 16.

*Remarks*:—Usually observed as immature specimens without the uniserial chambers.

*Hypotype*:—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625767.

*Occurrence*:—Fairly common in the Tocuyo and Pozón formations below the *Globorotalia menardii mendarii*/*Globigerina nepenthes* Zone.

**SchenckIELLA** *pallida* (Cushman)

*Clavulina communis* d'Orbigny var. *pallida* Cushman, 1927, Calif. Univ. Scripps Inst. Oceanography, Bull. Tech. Ser., vol. 1, p. 138, pl. 3, fig. 1.

*Listerella pallida* (Cushman), Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. 8, p. 147, pl. 16, figs. 37-39.

*SchenckIELLA pallida* (Cushman), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 163, pl. II, figs. 17-18.

*Hypotype*:—From sample, No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625769.

*Occurrence*:—Common in all zones of the Tocuyo and Pozón formations below and in the lower part of the *Sphaeroidinella seminulina* Zone.

Genus **TEXTULARIELLA** Cushman, 1927

**Textulariella** *miocenica* Cushman

*Textulariella miocenica* Cushman, 1936, Cushman Lab. Foram. Res., Spec. Pub. 6, p. 45, pl. 6, figs. 17, 19.

*Hypotype*:—From sample, No. RM 19112, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625771.

*Occurrence*:—Fairly common in the *Catapsydrax stainforthi* Zone and the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations but only observed as single specimens in isolated

samples from the *Globorotalia fohsi barisanensis* Zone, Pozón formation.

Genus **VALVULINA** d'Orbigny, 1826

**Valvulina flexis** Cushman and Renz

*Valvulina flexis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 7, figs. 16-17.

*Hypotype*:—From sample, No. RM 19210, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625773.

*Occurrence*:—Only observed in arenaceous facies faunas from the *Catapsydrax stainforthi* Zone, and from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

Family **MILIOLIDAE**

Genus **PYRGO** Defrance, 1824

**Pyrgo** spp. indet.

*Remarks and occurrence*:—A number of specimens of this genus occur in the *Sphaeroidinella seminulina* and *Globigerina bulloides* Zones, Pozón formation but are always abraded, broken or merely preserved as steinkerns and cannot be safely speciated.

Genus **QUINQUELOCULINA** d'Orbigny, 1826

**Quinqueloculina** spp. indet.

*Remarks and occurrence*:—A number of specimens of this genus occur in the *Sphaeroidinella seminulina* and *Globigerina bulloides* Zones, Pozón formation but are always abraded, broken, or merely preserved as steinkerns and cannot be safely speciated.

Genus **SIGMOILINA** Schlumberger, 1887

**Sigmoilina celata** (Costa)

*Spiroloculina celata* Costa, 1855, R. Accad. Sci. Napoli, Mem., vol. 2, p. 126, pl. 1, fig. 14 (*vide* Ellis and Messina, 1940 *et seq.*).

*Sigmoilina celata* (Costa), Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 82.

*Hypotype*:—From sample, No. RM 19151, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625775.

*Occurrence*:—Generally scarce but observed in samples from all zones of the Tocuyo and Pozón formations below, and in the lower part of the *Sphaeroidinella seminulina* Zone.

Genus **TRILOCULINA** d'Orbigny, 1826

**Triloculina** spp. indet.

*Remarks and occurrence*:—A number of specimens of this

genus occur in the *Sphaeroidinella seminulina* and *Globigerina bulloides* zones, Pozón formation, but are always abraded, broken or merely preserved as steinkerns and cannot be safely speciated.

#### Family TROCHAMMINIDAE

Genus **TROCHAMMINA** Parker and Jones, 1859

**Trochammina** cf. *pacifica* Cushman Pl. 7, fig. 6

cf. *Trochammina pacifica* Cushman, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, No. 11, p. 39, pl. 6, fig. 3 (*vide* Ellis and Messina, 1940 *et seq.*).

*Trochammina* cf. *pacifica* Cushman, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 172, pl. III, figs. 4a-b, 5a-b.

*Remarks:*—The writer's specimens are similar to those illustrated by Renz (1948). Most specimens occur as axially compressed forms and do not allow unambiguous specific identification. Renz's remarks (1948, p. 173) apply to the writer's specimens.

*Hypotype:*—From sample, No. RM 19849, auger line near Pozón, eastern Falcón; Plate 7, fig. 6, deposited in U.S.N.M. collection, No. 625777.

*Occurrence:*—Occasional specimens have been observed in the uppermost part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone but the species only becomes common in the lower and middle parts of the *Sphaeroidinella seminulina* Zone. Rather scarce in the upper part of this latter zone and in the basal part of the overlying *Globigerina bulloides* Zone, Pozón formation.

#### Family LAGENIDAE

Genus **ASTACOLUS** Montfort, 1808

**Astacolus** *ovatus* Galloway and Heminway Pl. 6, fig. 7

*Astacolus ovatus* Galloway and Heminway, 1941, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Islands, p. 334, pl. 8, figs. 10a-b.

*Remarks:*—This species shows a trace of a faint keel on the slightly convex dorsal side. Initial coil consisting of 5-6 chambers which appear to be in contact with the proloculum. Sutures of the later chambers strongly convex towards the aperture, meeting the dorsal side obliquely; test oval in cross-section.

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 6, fig. 7, deposited in U.S.N.M. collection, No. 625779.

*Occurrence*:—Scarce in samples from the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations. Also occurs in isolated samples from the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

Genus **DENTALINA** d'Orbigny, 1826

**Dentalina cf. advena** (Cushman)

cf. *Nodosaria advena* Cushman, 1923, U.S. Nat. Mus., Bull. 104, p. 79, pl. 14, fig. 12 (*vide* Ellis and Messina, 1940 *et seq.*).

*Dentalina cf. advena* (Cushman), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 130, pl. IV, fig. 27.

*Hypotype*:—From sample, No. RM 19281, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625780.

*Occurrence*:—Only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

Genus **FRONDICULARIA** DeFrance, 1826

**Frondicularia advena** Cushman

*Frondicularia inaequalis* Brady (*non* Costa), 1884, Challenger Exped. Rep., Zool., vol. 9, p. 521, pl. 66, figs. 8-12.

*Frondicularia advena* Cushman, 1923, U.S. Nat. Mus., Bull. 104, p. 141, pl. 20, figs. 1-2 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19435, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection No. 625781.

*Occurrence*:—Only observed in isolated samples from the *Globorotalia fohsi lobata* and *Globorotalia fohsi robusta* Zones, also from the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

**Frondicularia alazanensis** Nuttall

*Frondicularia alazanensis* Nuttall, 1932, Jour. Pal., vol. 6, p. 17, pl. 3, fig. 15.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625783.

*Occurrence*:—Scarce, observed in samples from the *Catapsydrax stainforthi* Zone, Tocuyo formation, and in the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone and *Globorotalia fohsi fohsi* Zone, Pozón formation.

**Frondicularia inaequalis** Costa

*Frondicularia inaequalis* Costa, 1855, R. Acad. Sci. Napoli, Mem., vol. 2, p. 372, pl. 3, fig. 3 (*vide* Ellis and Messina, 1940 *et seq.*).

*non Frondicularia inaequalis* Brady, 1884, Challenger Exped. Rep., Zool., vol. 9, p. 521, pl. 66, figs. 8-12.

*Hypotype*:—From sample, No. RM 19450, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection No. 625784.

*Occurrence*:—Only seen in a few samples from the *Globorotalia fohsi robusta* Zone, Pozón formation.

***Frondicularia sagittula lanceolata* van den Broeck**

*Frondicularia alata* Brady (*non* d'Orb.), 1884, Challenger Exped. Rep., Zool., vol. 9, p. 522, pl. 44, figs. 3-5.

*Frondicularia sagittula* var. *lanceolata* van den Broeck, Cushman, 1923, U.S. Nat. Mus., Bull. 104, pl. 4, p. 143, pl. 20, fig. 4, pl. 21, fig. 1 (*vide* Renz, 1948).

*Remarks*:—This form shows great variation within the Tocuyo and Pozón formations, and it is difficult to decide upon characters that are constant for the species and subspecies. The size and relative thickness of the test are subject to variation as is also the relative size of the proloculum in megalospheric forms. Only megalospheric forms have been recognized in the Falcón material. Occasional isolated prolocula have also been observed.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625785.

*Occurrence*:—Generally rather scarce throughout the Tocuyo and Pozón formations below the base of the *Sphaeroidinella seminulina* Zone.

Genus **LAGENA** Walker and Jacob, 1798

***Lagena asperoides* Galloway and Morrey**

Pl. 6, fig. 8

*Lagena asperoides* Galloway and Morrey, 1929, Bull. Amer. Pal., vol. 15, No. 55, p. 19, pl. 2, fig. 6.

*Remarks*:—A distinctive species, thick walled, and with a spherical chamber supporting a rather long neck; wall pustulose with rounded papillae.

*Hypotype*:—From sample, No. RM 19180, auger line near Pozón, eastern Falcón; Plate 6, fig. 8, deposited in U.S.N.M. collection, No. 625787.

*Occurrence*:—Renz (1948) did not record this species from the Agua Salada group but Cushman and Stainforth (1945) re-

corded its occurrence in the Cipero formation of southern Trinidad. In eastern Falcón it occurs, but rarely, in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

**Lagena nuttalli** Galloway and Heminway

Pl. 6, fig. 9

*Lagena nuttalli* Galloway and Heminway, 1941, New York Acad. Sci. Surv. Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 346, pl. 10, fig. 8.

*Remarks:*—The neck of this species is enlarged forming almost a second chamber; ornamented with longitudinal costae.

*Hypotype:*—From sample, No. RM 19179, auger line near Pozón, eastern Falcón; Plate 6, fig. 9, deposited in U.S.N.M. collection, No. 625788.

*Occurrence:*—Not recorded by Renz (1948) in the Agua Salada group but is comparatively common in the Cipero formation of southern Trinidad (Cushman and Stainforth, 1945). Observed infrequently in samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

Genus **LAGENONODOSARIA** Silvestri, 1900

**Lagenonodosaria acostaensis** Blow, sp. nov.

Pl. 7, fig. 10

*Diagnosis:*—Test fairly large, consisting of three to four globular or subglobular chambers, separated by fairly deeply incised sutures; last chamber with a long, slender, sometimes slightly hispid neck with a phialine lip; neck without multiple collars; test generally strongly costate and costae often produced into short spines over the posterior part of each chamber; costae become weak or absent in the sutural regions also over the first formed chamber; last chamber slightly more separated from the penultimate chamber than is the case with the earlier chambers; often with a pronounced basal spine; maximum length of holotype, 0.62 mm.

*Remarks:*—This form is distinguished from *L. scalaris* (Batsch) by the presence of more deeply incised sutures and the absence of multiple collars on the long narrow neck.

*Holotype:*—From sample, No. RM 19444, auger line near Pozón, eastern Falcón; Plate 7, fig. 10, deposited in the U.S.N.M. collection, No. 625693.

*Occurrence*:—Generally scarce in the *Globigerinatella insueta* Zone (*s.l.*) but becomes fairly common in the *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

Genus **LINGULINA** d'Orbigny, 1826

**Lingulina grimsdalei** Cushman and Renz

*Lingulina grimsdalei* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 14, pl. 3, fig. 1.

*Hypotype*:—From sample, No. RM 19150, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625789.

*Occurrence*:—Scarce, only observed in isolated samples from the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation.

**Lingulina prolata** (Guppy)

*Gonatosphaera prolata* Guppy, 1894, Zool. Soc. London, Proc., p. 651, pl. 41, figs. 14-19 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625790.

*Occurrence*:—Rare, only observed in samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

Genus **MARGINULINA** d'Orbigny, 1826

**Marginulina cf. striatula** Cushman

cf. *Marginulina striatula* Cushman, 1913, U.S. Nat. Mus., Bull. 71, p. 79, pl. 23, fig. 4 (*vide* Ellis and Messina, 1940 *et seq.*).

*Marginulina cf. striatula* Cushman, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 145, pl. IV, figs. 15-16.

*Remarks*:—The specimens observed by the writer are similar to those figured by Renz (1948) and tentatively referred to *Marginulina striatula* Cushman. Cushman mentioned the presence of fine costae on his specimens, but these are not present on the writer's material, nor are they shown on Renz's illustrations.

*Hypotype*:—From sample, No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625792.

*Occurrence*:—Generally scarce and only observed in isolated samples from the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation; also from the *Globigerinatella insueta*/*Globigerinoides bispherica* Sub-

zone, *Globorotalia fohsi* "Zone" (*s.l.*), and *Globorotalia mayeri* Zone (*s.l.*) and *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Marginulina subbullata* Hantken**

*Marginulina subbullata* Hantken, Palmer, 1940, Soc. Cubana hist. nat., Mem., vol. 14, No. 4, p. 279.

*Remarks*:—The megalospheric forms show only two chambers in the initial coil, and the sutures of the last chambers become horizontal resembling some species ascribed by Loeblich and Tappan (1955) to their new genus *Pandaglandulina*. The microspheric forms have between three and five chambers in the initial coil.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, near Falcón; deposited in U.S.N.M. collection, No. 625794.

*Occurrence*:—Generally ubiquitous throughout the Tocuyo formation and nearly all of the Pozón formation but does not occur in the rather shallow-water assemblages of the *Globigerina bulloides* Zone. Common in the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*), and in the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

Genus **MARGINULINOPSIS** Silvestri, 1904

***Marginulinopsis basispinosus* (Cushman and Renz)**

Pl. 6, fig. 11

*Marginulina basispinosa* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 13, pl. 2, figs. 16-18.

*Marginulinopsis basispinosus* (Cushman and Renz), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 145, pl. 1V, figs. 8a-b, 9, 10.

*Remarks*:—This form has an initial coil of between three and five chambers in contact with the proloculum followed by usually 3-5, uniserial chambers arranged at right-angles to the axis of coiling. The species is rather variable; some forms show the initial coil and first chamber of the uniserial part rather compressed or triangular in cross-section, in others all the chambers are rounded or elliptical. Ornamentation may be either costate or papillate or a combination of both, whilst in some forms ornamentation is wanting on the last two or three chambers and much reduced on the earlier chambers. Often with several radially directed spines on the initial coiled chambers.

*Hypotype*:—From sample, No. RM 20025, auger line near Pozón, eastern Falcón; Plate 6, fig. 11, deposited in U.S.N.M. collection, No. 625796.

*Occurrence*:—Renz (1948) used the occurrence of this species to define his *Marginulinopsis basispinosus* Zone, Pozón formation, (= upper part *Globorotalia mayeri* Zone (*s.l.*), *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and basal part *Sphaeroidinella seminulina* Zone). In the Falcón region it is restricted to this interval, but evidence seen in subsurface sections on the Island of Cubagua shows that it ranges higher into the *Sphaeroidinella seminulina* Zone, indicating that its disappearance in Pozón may be due to ecological rather than stratigraphical reasons.

Genus **NODOSARIA** Lamareck, 1812

*Nodosaria caribbeana* (Hedberg)

Pl. 6, fig. 12

*Nodosaria raphanistrum* (Linné) var. *caribbeana* Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 671, pl. 91, fig. 1.

*Remarks*:—Hedberg (1937, p. 671) stated “Due to the uncertainty regarding the exact characters possessed by Linné’s species, it seems desirable to make a new variety of the form common in the Tertiary of the Caribbean region.”

The writer feels that, in view of this uncertainty concerning Linné’s species and since this form is common in the Oligo-Miocene of the Caribbean, it should be considered as a distinct species.

The form shows a wide variability in the degree of constriction between adjacent chambers; even within the one specimen, well separated chambers occur adjacent to chambers practically in contact with each other. The costate ornamentation also shows great variability both within the species group and within a single specimen; in some cases the costae cross the septal necks unchanged whilst in others they become much weaker.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 6, fig. 12, deposited in U.S.N.M. collection, No. 625797.

*Occurrence*:—Common throughout the upper part of the Tocuyo formation, in the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone and in the *Globorotalia fohsi* “Zone” (*s.l.*).

Rather scarce in the *Globorotalia mayeri* Zone (*s.l.*), *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and *Sphaeroidinella seminulina* Zone (lower part), Pozón formation.

### ***Nodosaria comatus* (Batsch)**

*Nautilus comatus* Batsch, 1791, Testaceorum arenulae marinae tabulae sex . . . (Sechs Kupfertafeln mit Conchylien des Seesandes), pp. 1, 4 (*vide* Ellis and Messina, 1940 *et seq.*)

*Nodosaria comata* Brady, 1884, Challenger Exped. Rept., Zool., vol. 9, p. 509, pl. 64, figs. 1-5.

*Nodosaria comatula* Cushman, 1923, U.S. Nat. Mus., Bull. 104, pt. 3, p. 83, pl. 14, fig. 5 (*vide* Renz 1948).

*Pseudoglandulina comatula* (Cushman), Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 87.

*Remarks*:—Loeblich and Tappan (1955) discussed the validity of the genus *Pseudoglandulina* Cushman (the type species of which is this species) and they pointed out that *Pseudoglandulina* Cushman, 1929 must be considered a junior synonym of *Nodosaria* Lamarck, 1812, and is, therefore, invalid.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625799.

*Occurrence*:—Although Renz (1948) only reported this species from the *Robulus wallacei* Zone and *Siphogenerina transversa* Zone (= *Catapsydrax stainforthi* Zone to lower part *Globorotalia fohsi fohsi* Zone), the present writer has observed this form in the *Globorotalia fohsi lobata* and *Globorotalia fohsi robusta* Zones, and the *Globorotalia mayeri* Zone (*s.l.*); furthermore, occasional specimens have been observed in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and the lowermost part of *Sphaeroidinella seminulina* Zone, Pozón formation.

It is associated in the Pozón formation with mainly planktonic assemblages and is absent in faunas containing abundant *Uvigerina isidroensis*, *Bolivina imporcata* and *Bolivina simplex*; the abundance of these latter forms suggests rather shallow-water conditions.

Brady (1884) and others recorded the occurrence of this species at depths of circa 800 metres.

### ***Nodosaria? longiscata* d'Orbigny**

*Nodosaria longiscata* d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne (Autriche), p. 32, pl. 1, figs. 10-12. (*Fide* Ellis and Messina, 1940 *et seq.*).

*Remarks:*—This distinctive and well-known species is characterized by the elongate but narrow chambers with rather poorly defined constrictions between adjacent chambers. Specimens showing bulbous, inflated prolocula are not infrequent. In the material from Pozón, specimens showing the form and characters of the aperture have not been observed, and, therefore, unambiguous generic identification is not possible. Some broken specimens show in end view what appears to be a multiple wall structure consisting of two rather thick concentric layers. It is doubtful if D'Orbigny's drawing of an end view actually shows the aperture but more likely an end view of a broken specimen. In view of the absence of specimens showing undoubted apertural characters this species is only doubtfully referred to the genus *Nodosaria*.

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection No. 625800.

*Occurrence:*—Common in the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation and in the Pozón formation below the *Globorotalia mayeri* Zone (*s.l.*); scarce in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

#### ***Nodosaria nuttalli* Hedberg**

*Nodosaria nuttalli* Hedberg, 1937, Jour. Pal., vol. 11, p. 673, pl. 91, fig. 6.

*Hypotype:*—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625802.

*Occurrence:*—Fairly common or common in the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation; also in the *Globigerinatella insueta*/*Globigerinoides bisphérica* Subzone, *Globorotalia fohsi* "Zone" (*s.l.*), Pozón formation.

#### ***Nodosaria schlichti* Reuss**

*Nodosaria (Nodosaria) schlichti* Reuss, 1870, K. Akad. Wiss. Wien, Math.-Naturw. Cl., Sitzber., vol. 62, Abt. 1, p. 472, pl. 6, figs. 29-31 (*fide* Ellis and Messina 1940 *et seq.*).

*Nodosaria schlichti* Reuss, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 147, pl. IV, fig. 25, pl. V, fig. 5.

*Hypotype:*—From sample, No. RM 19283, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625804.

*Occurrence*:—Generally scarce but observed in all zones below the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Tocuyo and Pozón formations.

***Nodosaria stainforthi* Cushman and Renz**

*Nodosaria stainforthi* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 15, pl. 3, fig. 4.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625806.

*Occurrence*:—Generally scarce in the upper part of the Tocuyo formation and in the Pozón formation, below the *Globorotalia mayeri* Zone (*s.l.*), but sometimes several specimens occur in single samples from the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone where the faunas are suggestive of a deeper than usual environment.

***Nodosaria vertebralis* (Batsch)**

*Nautilus (Orthoceras) vertebralis* Batsch, 1791, Testaceorum arenulae marinae tabulae sex... (Sechs Kupfertafeln mit Conchylien des Seesandes), pt. 3, No. 6, pl. 2, figs. 6a-b. (*fide* Ellis and Messina, 1940 *et seq.*).

*Nodosaria vertebralis* (Batsch), Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 671, pl. 91, fig. 2.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625808.

*Occurrence*:—As for *Nodosaria stainforthi* with which it is often associated.

Genus **PLANULARIA** DeFrance, 1824

***Planularia clara* Cushman and Jarvis**

*Planularia clara* Cushman and Jarvis, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, pt. 1, p. 7, pl. 2, figs. 14-15.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625809.

*Occurrence*:—Although Renz (1948) recorded this form not higher than his *Valvulineria herricki* Zone, Pozón formation, the writer has observed specimens associated with *Marginulinopsis basispinosus*. It is rare in the *Globigerinatella insueta* Zone (*s.l.*) but becomes fairly common in the *Globorotalia fohsi* "Zone (*s.l.*). Isolated specimens occur in the *Globorotalia mayeri* Zone (*s.l.*), the

*Globorotalia menardii menardii*/*Globigerina nepenthes* Zones and in the lowermost part of the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Planularia venezuelana* Hedberg**

*Planularia venezuelana* Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 670, pl. 90 figs. 14a-b.

*Hypotype*:—From sample, No. RM 19281, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625811.

*Occurrence*:—Scarce and only observed in the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, Tocuyo and Pozón formations.

Genus **PSEUDONODOSARIA** Boomgaart, 1949

According to Loeblich and Tappan (1955, p. 6), this genus was defined by Boomgaart as follows:

Test free, uniserial and rectilinear throughout, chambers embracing strongly in the early portion, later chambers inflated, less embracing and separated by constricted sutures; sutures horizontal; aperture terminal, radiate.

***Pseudonodosaria incisa* (Neugeboren)**

Pl. 7, fig. 13

*Glandulina incisa* Neugeboren, 1850, Siebenb. Ver. Naturw., Hermannstadt, Verh. Mitt., Jahr. 1, No. 4, p. 52, pl. 1, figs. 7a-b (*vide* Ellis and Messina, 1940 *et seq.*).

*Pseudoglandulina incisa* (Neugeboren), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 154, pl. V, fig. 16.

*Remarks*:—This species has the characters required for inclusion in Boomgaart's genus. It has no trace of a biserial early stage. The early chambers are strongly embracing whilst the last chamber is well separated from the earlier chambers and fairly inflated. Aperture terminal, radiate.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; Plate 7, fig. 13, deposited in U.S.N.M. collection, No. 625813.

*Occurrence*:—Generally scarce and often occurs as single specimens in samples from the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, *Globigerinatella insueta*/*Globigerina bispherica* Subzone, *Globorotalia fohsi* "Zone" (*s.l.*), *Globorotalia mayeri* Zone (*s.l.*), and *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Tocuyo and Pozón formations.

Genus **RECTOGLANDULINA** Loeblich and Tappan, 1955

Loeblich and Tappan (1955), gave the following diagnosis for their genus:

Test free, uniserial, with chambers increasing rapidly in diameter and strongly overlapping, sutures horizontal and parallel, never strongly depressed; wall calcareous; aperture terminal, radiate.

Loeblich and Tappan further remarked that *Rectoglandulina* differs from *Pseudonodosaria* Boomgaart, 1949 in having all the chambers closely appressed and with the later chambers not separated by constricted sutures.

**Rectoglandulina gallowayi paucicostata** (Cushman and Renz)

Pl. 6, fig. 14

*Pseudoglandulina gallowayi* Cushman var. *paucicostata* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 16, pl. 3, fig. 5.

*Remarks:*—This species appears to have the characters required for inclusion in *Rectoglandulina*. The last suture is only slightly constricted. The strongly costate ornamentation makes it difficult to judge to what extent the chambers overlap.

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 6, figure 14, deposited in U.S.N.M. collection, No. 625814.

*Occurrence:*—Generally rather scarce and only observed in samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

Genus **ROBULUS** Montfort, 1808

**Robulus americanus** (Cushman)

*Cristellaria americana* Cushman, 1918, U.S. Geol. Surv., Bull. 676, p. 50, pl. 10, figs. 5-6.

*Robulus americanus* (Cushman), Cushman and Cahill, 1933, U.S. Geol. Surv., Prof. Paper 175-A, p. 12, pl. 3, figs. 6a-c.

*Hypotype:*—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625815.

*Occurrence:*—Generally common throughout all zones of the Tocuyo and Pozón formations below the *Globigerina bulloides* Zone, in which only isolated specimens occur. The species varies considerably in frequency from sample to sample throughout the suc-

cession, being rare in samples containing abundant *Uvigerina isidroensis*, *Bolivina simplex*, and *Bolivina imporcata*.

***Robulus americanus grandis* (Cushman)**

*Cristellaria americana* Cushman var. *grandis* Cushman, 1920, U.S. Geol. Surv. Prof. Paper 128-B, p. 68, pl. 11, fig. 2 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625816.

*Occurrence*:—Fairly common in most zones below the *Globigerina bulloides* Zone, Pozón formation, but varies considerably in frequency from sample to sample. General distribution is similar to the parent species.

***Robulus americanus spinosus* (Cushman)**

*Cristellaria americana* Cushman var. *spinosus* Cushman, 1918, U.S. Geol. Surv., Bull. 676, p. 51, pl. 10, fig. 7.

*Remarks*:—This subspecies is distinguished from the parent species by the spines which extend radially from the peripheral part of the sutures. The spines are variable, both in length and thickness.

*Hypotype*:—From sample, No. RM 19181, auger line Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625817.

*Occurrence*:—Generally scarce in the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations. It becomes fairly common or common in the *Globorotalia mayeri* Zone (*s.l.*), *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and in the lower part of the *Sphaeroidinella seminulina* Zone, Pozón formation. Isolated specimens also occur in the upper part of the *Sphaeroidinella seminulina* Zone and in the *Globigerina bulloides* Zone. This subspecies seems to prefer a somewhat shallower environment than the parent species.

***Robulus arcuato-striatus caroliniannus* Cushman**

*Robulus arcuato-striatus* (Hantken) var. *carolinianus* Cushman, 1933, Cushman Lab. Foram. Res., Contr., vol. 9, p. 4, pl. 1, fig. 9 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625818.

*Occurrence*:—Scarce and only observed in isolated samples from the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Robulus calcar* (Linné)**

*Nautilus calcar* Linné, 1767, *Systema naturae*, 12th ed., vol. 1, p. 1162, No. 272 (*vide* Renz, 1948.).

*Robulus calcar* (Linné), Galloway and Morrey, 1929, *Bull. Amer. Pal.*, vol. 15, No. 55, p. 20, pl. 2, fig. 10.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625819.

*Occurrence*:—Generally common in the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations. It becomes scarce and sporadic in occurrence within the *Globorotalia menardii menardii* *Globigerina nepenthes* Zone and in the *Sphaeroidinella seminulina* Zone; occasional specimens have been observed in the *Globigerina bulloides* Zone, Pozón formation.

***Robulus clericii* (Fornasini)**

*Robulus clericii* (Fornasini), Cushman, 1929, *Cushman Lab. Foram. Res.*, Contr., vol. 5, p. 84, pl. 12, figs. 16-17.

*Remarks*:—Renz (1948, p. 158) discussed the variability of this form within the Agua Salada group and pointed out that this species and *Robulus chambersi* Garrett, 1939 can only be distinguished in extreme cases.

*Hypotype*:—From sample, No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625820.

*Occurrence*:—Generally fairly common in all zones of the Tocuyo and Pozón formations below the *Globorotalia menardii menardii* *Globigerina nepenthes* Zone. Occasional specimens have been observed in the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Robulus formosus* (Cushman)**

*Cristellaria formosa* Cushman, 1923, *U.S. Nat. Mus.*, *Bull.* 104, pt. 4, p. 110, pl. 29, fig. 1; pl. 30, fig. 1 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19182, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625822.

*Occurrence*:—Scarce and only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*), and in the *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations.

***Robulus hedbergi* Cushman and Renz**

*Robulus hedbergi* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 10, pl. 2, fig. 9.

*Hypotype*:—From sample, No. RM 19112, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625823.

*Occurrence*:—Scarce and only seen in isolated samples from the *Catapsydrax stainforthi* Zone and the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

***Robulus iotus* (Cushman)**

*Cristellaria iota* Cushman, 1923, U.S. Nat. Mus., Bull. 104, p. 111, pl. 29, fig. 2; pl. 30, fig. 1 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19178, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625824.

*Occurrence*:—Scarce, only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*) and in the *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations.

***Robulus melvilli* Cushman and Renz**

*Robulus melvilli* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 12, pl. 2, fig. 12.

*Hypotype*:—From sample, No. RM 19116, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625825.

*Occurrence*:—Generally scarce but observed throughout all zones of the Tocuyo and Pozón formations, below the middle part of the *Sphaeroidinella seminulina* Zone.

***Robulus nuttalli* Cushman and Renz**

*Robulus nuttalli* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 11, pl. 2, fig. 10.

*Hypotype*:—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625826.

*Occurrence*:—Generally scarce and only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), and from the *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Robulus occidentalis torridus* (Cushman)**

*Cristellaria occidentalis* Cushman var. *torrida* Cushman, 1923, U.S. Nat. Mus., Bull. 104, p. 105, pl. 25, fig. 1 (*vide* Ellis and Messina, 1940 *et seq.*).

*Robulus occidentalis* (Cushman) var. *torridus* (Cushman), Cushman and Jarvis, 1930, Jour. Pal., vol. 4, No. 4, p. 357, pl. 32, figs. 8a-b.

*Hypotype*:—From sample, No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625827.

*Occurrence*:—Fairly common in all zones of the Tocuyo and Pozón formations below the *Sphaeroidinella seminulina* Zone.

***Robulus protuberans* (Cushman)**

*Cristellaria protuberans* Cushman, 1918, U.S. Nat. Mus., Bull. 103, p. 61, pl. 22, fig. 2 (*vide* Ellis and Messina, 1940 *et seq.*).

*Robulus protuberans* (Cushman), Galloway and Heminway, 1941, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 351, pl. 11, figs. 13a-b.

*Hypotype*:—From sample, No. RM 19151, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625828.

*Occurrence*:—Scarce, only observed in isolated samples from the *Globigernatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation.

***Robulus senni* Cushman and Renz**

Pl. 6, fig. 15

*Robulus senni* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 12, pl. 2, figs. 14-15.

*Remarks*:—This form shows considerable variation in the degree of uncoiling and thickness of the test. Earlier forms seem to be thicker and less uncoiled than later forms. It is possible that it may be related to *Robulus subaculeatus glabratus* Cushman.

*Hypotype*:—From sample, No. RM 19820, auger line near

Pozón, eastern Falcón; Plate 6, figure 15, deposited in U.S.N.M. collection, No. 625829.

*Occurrence*:—Common in the upper part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and in the *Sphaeroidinella seminulina* Zone, Pozón formation. Renz (1948) used the partial occurrence of this species to define his *Robulus senni* Zone. The upper boundary of this *Robulus senni* Zone is strongly influenced by facies with the incoming of somewhat impoverished facies faunas in the Pozón area; whilst at El Mene de Acosta, environmental conditions were such that the "normal" faunas of the *Robulus senni* Zone continued to a higher stratigraphical level. Hence, the upper boundary of the "zone" is strongly diachronous between the two areas. Indeed, in the Pozón-El Mene Road section there is an alternation and interdigitation of facies so that it is not always possible to separate unambiguously the *Robulus senni* "Zone" from the *Trochammina* cf. *pacifica*-*Vaginulinopsis superbus* Zone.

***Robulus subaculeatus glabratus* (Cushman)**

*Cristellaria subaculeata* Cushman var. *glabrata* Cushman, 1923, U.S. Nat. Mus., Bull. 104, p. 124, pl. 32, fig. 4 (*vide* Ellis and Messina, 1940 *et seq.*).  
*Robulus subaculeatus* (Cushman) var. *glabratus* (Cushman), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 160, pl. III, figs. 20-21.

*Remarks*:—This subspecies shows considerable variation in morphology. The earlier forms are often tightly coiled and have a generally stoutly built test with strongly developed ornamentation. Later forms show a considerable degree of uncoiling with less well-developed ornamentation and a somewhat more compressed test.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625830.

*Occurrence*:—Common in the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta* Zone (*s.l.*), Tocuyo formation and Pozón formation; also in the *Globorotalia fohsi* "Zone" (*s.l.*), and the *Globorotalia mayeri* Zone (*s.l.*); occasional specimens have been observed in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Robulus suteri* Cushman and Renz**

*Robulus suteri* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 10, pl. 2, figs. 5-8.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625832.

*Occurrence*:—Generally scarce but observed in samples from all zones of the Tocuyo and Pozón formations below the top of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone.

***Robulus vortex* (Fichtel and Moll)**

*Nautilus vortex* Fichtel and Moll, 1798, Test. Micro., p. 33, pl. 2, figs. d-i (*vide* Ellis and Messina, 1940 *et seq.*).

*Cristellaria vortex* (Fichtel and Moll), Brady, 1884, Challenger Exped., Rept. Zool., vol. 9, p. 548, pl. 69, figs. 14-16.

*Robulus vortex* (Fichtel and Moll), Renz, 1948, Geol. Soc., Amer., Mem. 32, p. 161.

*Hypotype*:—From sample, No. RM 19340, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625834.

*Occurrence*:—Scarce, only observed in isolated samples from the *Globorotalia fohsi* "Zone" (*s.l.*), Pozón formation.

***Robulus wallacei* (Hedberg)**

Pl. 6, figs. 16, 17

*Marginulina wallacei* Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 670, pl. 90, figs. 15-17.

*Robulus wallacei* (Hedberg), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 161, pl. IV, figs. 19-20.

*Remarks*:—Hedberg described this form as belonging to the genus *Marginulina*, but Renz included the species in the genus *Robulus*. It shows considerable variation in morphology. The earlier forms are closely coiled with well-developed ornamentation and with characteristic tangential "cross-bars". The later forms show the last 2-3 chambers uncoiled and often devoid of ornamentation. In the uncoiled forms, the last chamber may be rather pointed and the aperture subterminal and not peripheral as in the earlier more tightly coiled chambers. Ornamentation is variable and generally later forms show a rather more weakly developed ornamentation.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; Plate 6, figure 17, deposited in U.S.N.M. collection, No. 625835; Plate 6, figure 16, from sample RM 19179, also deposited in U.S.N.M. collection, No. 625836.

*Occurrence*:—Renz used this form to define his *Robulus wallacei* Zone, Tocuyo formation, which is equivalent to the *Catap-*

*sydrax stainforthi* Zone plus the *Globigerinatella insueta*/*Globigerinoides triloba* Subzone. It is often abundant in this interval to which it appears restricted.

Genus **SARACENARIA** Defrance, 1824

**Saracenaria italica acutocarinata** (Cushman)

*Cristellaria italica* (Defrance) var. *acutocarinata* Cushman, 1917, U.S. Nat. Mus., Proc., vol. 51, No. 2172, p. 661 (*fide* Renz, 1948).

*Saracenaria italica* Defrance var. *acutocarinata* (Cushman), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 162, pl. V, fig. 19.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625837.

*Occurrence*:—Scarce and only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

**Saracenaria italica carapitana** Franklin

*Saracenaria italica* Defrance var. *carapitana* Franklin, 1944, Jour. Pal., vol. 18, p. 312, pl. 45, fig. 14.

*Hypotype*:—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625839.

*Occurrence*:—Scarce and only occurs sporadically in samples from the *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

**Saracenaria latifrons** (Brady)

*Cristellaria latifrons* Brady, 1884, Challenger Exped., Rept., Zool., vol. 9, p. 544, pl. 113, figs. 11a-b.

*Saracenaria latifrons* (Brady), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 162, pl. V, fig. 22.

*Hypotype*:—From sample, No. RM 19279, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625841.

*Occurrence*:—Scarce and only observed in isolated samples from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, and the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

**Saracenaria schencki** Cushman and Hobson

*Saracenaria schencki* Cushman and Hobson, 1935, Cushman Lab. Foram. Res., Contr., vol. 11, pt. 3, p. 57, pl. 8, fig. 11 (*fide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19116, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625843.

*Occurrence*:—Scarce but occurs sporadically in isolated samples from all zones of the Tocuyo and Pozón formations below and in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone.

***Saracenaria senni* Hedberg**

*Saracenaria senni* Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 674, pl. 90, figs. 18a-b.

*Hypotype*:—From sample, No. RM 19116, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625845.

*Occurrence*:—Scarce, only seen in isolated samples from the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation.

Genus **VAGINULINA** d'Orbigny, 1826

***Vaginulina alazanensis* Nuttall**

*Vaginulina alazanensis* Nuttall, 1932, Jour. Pal., vol. 6, No. 1, p. 17, pl. 1, fig. 11.

*Hypotype*:—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625847.

*Occurrence*:—Scarce, only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi barisanensis* Zone and *Globorotalia fohsi fohsi* Zone, Tocuyo and Pozón formations.

***Vaginulina subtilius* (Nuttall)**

Pl. 7, fig. 18

*Astacolus subtilius* (Nuttall), Galloway and Hemmingsway, 1941, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 335, pl. 8, figs. 11a-b.

*Remarks*:—The initial coil is small, consisting of three or four chambers in contact with the proloculum. Sutures of the later chambers are directed towards the aperture at the ventral margin but become transverse and horizontal, meeting the dorsal margin very nearly at right angles. Test much compressed. This species

seems to be best placed in the genus *Vaginulina* as emended by Bartenstein (1948).

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; Plate 7, figure 18, deposited in U.S.N.M. collection, No. 625849.

*Occurrence*:—Fairly common in the *Catapsydrax stainforthi* Zone and recorded in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

#### Genus **VAGINULINOPSIS** Silvestri, 1904

**Vaginulinopsis superbus** (Cushman and Renz) Pl. 6, fig. 19

*Marginulina superba* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 14, pl. 2, figs. 19-20.

*Vaginulinopsis superbus* (Cushman and Renz), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 177, pl. IV, figs. 17a-b, 18.

*Hypotype*:—From sample, No. RM 19849, auger line near Pozón, eastern Falcón; Plate 6, fig. 19, deposited in U.S.N.M. collection, No. 625850.

*Remarks*:—Occasional specimens have been observed in the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, becoming fairly common in the lower part of the *Sphaeroidinella seminulina* Zone but rather scarce in the middle to upper part of the same zone. It does not persist into the *Globigerina bulloides* Zone.

#### Family **POLYMORPHINIDAE**

##### Genus **GLANDULINA** d'Orbigny, 1826

**Glandulina laevigata** d'Orbigny

*Nodosaria (Glandulina) laevigata* d'Orbigny, 1826, Ann. Sci. Nat., Paris, sér. 1, vol. 7, p. 252, pl. 10, figs. 1-3 (*fide* Ellis and Messina, 1940 *et seq.*).

*Pseudoglandulina laevigata* (d'Orbigny), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 154, pl. V, figs. 14-15.

*Remarks*:—The specimens observed by the writer appear to be typical of the species and show the biserial early stage.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625852.

*Occurrence*:—Generally scarce, but observed in all zones of the Tocuyo and Pozón formations below the *Sphaeroidinella seminulina*

*lina* Zone. Often occurs associated with mainly planktonic faunas.

Genus **GUTTULINA** d'Orbigny, 1839

**Guttulina irregularis** (d'Orbigny)

*Globulina irregularis* d'Orbigny, 1846, Foraminifères fossils du bassin tertiaire de Vienne (Autriche), p. 226, pl. 13, figs. 9-10. (*vide* Ellis and Messina, 1940 *et seq.*).

*Guttulina irregularis* (d'Orbigny), Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 64, pl. 9, figs. 10-12.

*Hypotype*:—From sample, No. RM 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625854.

*Occurrence*:—Scarce and only observed in a few isolated samples from the *Globigerinatella insueta*/*Globigerinoides triloba* Subzone and in the lower part of the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, Tocuyo formation. It is usually associated with mainly planktonic faunas.

**Guttulina jarvisi** Cushman and Ozawa

*Guttulina jarvisi* Cushman and Ozawa, 1930, U.S. Nat. Mus., Proc., vol. 77, No. 2829, p. 39, pl. 8, figs. 4-5.

*Hypotype*:—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625856.

*Occurrence*:—Scarce and only observed in a few samples from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, Pozón formation.

Family **NONIONIDAE**

Genus **ELPHIDIUM** Montfort, 1808

**Elphidium poeyanum** (d'Orbigny)

Pl. 7, fig. 20

*Polystomella poeyana* d'Orbigny, 1839, "Foraminifères" in de la Sagra, Histoire physique, politique et naturelle de l'île de Cuba, p. 55, pl. 6, figs. 25-26 (*vide* Ellis and Messina, 1940 *et seq.*).

*Elphidium poeyanum* (d'Orbigny), Cushman, 1930, U.S. Nat. Mus., Bull. 104, p. 25, pl. 10, figs. 4-5 (*vide* Renz, 1948).

*Remarks*:—A fairly distinctive form with rather inflated chambers and moderately depressed sutures. The retral processes are not well marked.

*Hypotype*:—From sample, No. RM 20131, auger line near Pozón, eastern Falcón; Plate 7, figure 20, deposited in U.S.N.M. collection, No. 625858.

*Occurrence*:—Observed in isolated samples from the upper part of the *Sphaeroidinella seminulina* Zone and infrequently in the lower part of the overlying *Globigerina bulloides* Zone, but becomes comparatively common in the higher part of this latter zone indicating an approach to brackish-water conditions. It is common in the Ojo de Agua formation which overlies the Pozón formation, where it is often associated with *Chara* seeds.

Genus **NONION** Montfort, 1808

**Nonion affinis** (Reuss)

*Nonionina affinis* Reuss, 1851, Deutsch. Geol. Ges., Zeitschr., vol. 3, p. 72, pl. 5, figs. 32a-b (*fide* Ellis and Messina, 1940 *et seq.*).

*Nonion affine* (Reuss), Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 89, pl. 13, fig. 24.

*Hypotype*:—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625860.

*Occurrence*:—Generally scarce but occurs in the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*), and *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations. This species of *Nonion* seems to occur in a possible deepwater environment as evidenced by its association with mainly planktonic faunas.

**Nonion costiferus\*** (Cushman)

*Nonionina costifera* Cushman, 1926, Cushman Lab. Foram. Res., Contr., vol. 1, p. 90, pl. 13 (*fide* Ellis and Messina, 1940 *et seq.*).

*Nonion costiferum* (Cushman), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 148, pl. VI, figs. 5a-b, pl. XII, figs. 6a-b.

*Hypotype*:—From sample, No. RM 19360, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625862.

*Occurrence*:—Ubiquitous, occurring in all zones of the upper Tocuyo and Pozón formations below and in the *Sphaeroidinella seminulina* Zone. Varies considerably in frequency and often associated with *Bolivina impercata* and *Uvigerina isidroensis*, suggestive of a rather shallow but clear water environment.

**Nonion incisus kernensis** Kleinpell

*Nonion incisum* (Cushman) var. *kernensis* Kleinpell, 1938, Amer. Assoc. Petr. Geol., Spec. Pub., p. 232.

*Nonion incisum* (Cushman) var. *kernensis* Kleinpell, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 148, pl. VI, figs. 4a-b.

\* Montfort used *Nonion* in masculine gender.—Ed.

*Hypotype*:—From sample, No. RM 19360, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625864.

*Occurrence*:—Similar to *Nonion costiferus* but often occurs as well with mainly shallow-water arenaceous assemblages in the *Sphaeroidinella seminulina* Zone and *Globigerina bulloides* Zone, Pozón formation.

***Nonion pompilioides* (Fichtel and Moll)**

*Nautilus pompilioides* Fichtel and Moll, 1798, *Testacea microscopica aliaque minuta ex generibus Argonauta et Nautilus*, p. 31, pl. 2, figs. a-c, 1803 reprint. (*Fide* Ellis and Messina, 1940 *et seq.*).

*Nonion pompilioides* (Fichtel and Moll), Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 89, pl. 13, figs. 25a-b.

*Hypotype*:—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625866.

*Occurrence*:—Fairly common in the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*), and *Globorotalia fohsi barisanensis* Zone, Tocuyo and Pozón formations. Also observed in isolated samples containing mainly planktonic assemblages from the *Globorotalia fohsi fohsi* Zone and *Globorotalia fohsi lobata* Zone, Pozón formation.

Family **HETEROHELICIDAE**

Genus **PLECTOFRONDICULARIA** Liebus, 1903

***Plectofrondicularia californica* Cushman and Stewart**

*Plectofrondicularia californica* Cushman and Stewart, 1926, Cushman Lab. Foram. Res., Contr., vol. 2, p. 39, pl. 6, figs. 9-11 (*fide* Ellis and Messina, 1940 *et seq.*).

*Plectofrondicularia californica* Cushman and Stewart, Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 90, pl. 13, figs. 18-19.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625868.

*Occurrence*:—Generally scarce and only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

***Plectofrondicularia floridana* Cushman**

*Plectofrondicularia floridana* Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 41, pl. 8, fig. 1 (*fide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625870.

*Occurrence*:—Fairly common in all zones of the Tocuyo and Pozón formations below the *Sphaeroidinella seminulina* Zone, but only observed as single specimens in isolated samples within the lower to middle part of this latter zone.

**Plectofrondicularia cf. longistriata** LeRoy

cf. *Plectofrondicularia longistriata* LeRoy, 1939, Natuurk. Tijdschr. Nederl. Indie, deel 99, afl. 6, p. 241, pl. 5, figs. 4-6 (*vide* Ellis and Messina, 1940 *et seq.*).

cf. *Plectofrondicularia longistriata* LeRoy, 1944, Colorado School Mines, Quart., vol. 39, No. 3, p. 25, pl. 1, fig. 51; pl. 5, fig. 38.

*Remarks*:—The specimens seen in Falcón are usually broken and fragmentary and, therefore, only tentatively referred to LeRoy's species, although they seem to agree in general characteristics. The costae are rather variable, sometimes being well developed and in other specimens being weakly developed.

*Hypotype*:—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625872.

*Occurrence*:—Scarce and only observed as single specimens in isolated samples from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, *Globorotalia fohsi* "Zone" (*s.l.*), *Globorotalia mayeri* Zone (*s.l.*) and *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

**Plectofrondicularia mansfieldi** Cushman and Ponton

*Plectofrondicularia mansfieldi* Cushman and Ponton, 1931, Cushman Lab. Foram. Res., Contr., vol. 7, p. 60, pl. 8, figs. 1a-b (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19410, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625874.

*Occurrence*:—Fairly common in *Globorotalia fohsi lobata* Zone and *Globorotalia fohsi robusta* Zone but scarce in the *Globorotalia mayeri* Zone (*s.l.*), the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and in the lower part of the *Sphaeroidinella seminulina* Zone, Pozón formation.

Family **BULMINIDAE**

Genus **ANGULOGERINA** Cushman, 1927

**Angulogerina illingi** Cushman and Renz

*Angulogerina illingi* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 21, pl. 3, figs. 19-20.

*Angulogerina yumuriana* Palmer, 1941, Soc. cubana hist. nat., Mem., vol. 15, No. 2, p. 186, pl. 15, fig. 8.

*Angulogerina illingi* Cushman and Renz, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 114, pl. VII, figs. 31, 32a-b.

*Remarks*:—Generally rather similar to *Angulogerina cooperensis* Cushman but has a more carinate and triangular test with a virtual absence of ornamentation.

*Hypotype*:—From sample, No. RM 19507, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625876.

*Occurrence*:—Only seen in isolated samples from the *Globorotalia fohsi robusta* Zone, and in the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

#### Genus **BOLIVINA** d'Orbigny, 1839

##### **Bolivina advena** Cushman

*Bolivina advena* Cushman, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, No. 8, p. 29, pl. 5, fig. 1 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19791, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625878.

*Occurrence*:—Scarce in the upper part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone but fairly common in the *Sphaeroidinella seminulina* Zone, Pozón formation.

##### **Bolivina alazanensis** Cushman

*Bolivina alazanensis* Cushman, 1926, Cushman Lab. Foram. Res., Contr., vol. 1, p. 82, pl. 12, figs. 1a-b (*vide* Ellis and Messina, 1940 *et seq.*).

*Remarks*:—The sutures of this form are distinctly limbate and the marginal part of the chambers strongly directed towards the initial end of the test. The median suture forms a distinct ridge.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625880.

*Occurrence*:—Only seen in isolated samples from the *Catapsydrax stainforthi* Zone, Tocuyo formation.

##### **Bolivina byramensis** Cushman

*Bolivina caclata* Cushman var. *byramensis* Cushman, 1923, U.S. Geol. Surv., Prof. Paper 133, p. 19, pl. 1, fig. 9.

*Bolivina byramensis* Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. 9, p. 69, pl. 8, figs. 18-20.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625882.

*Occurrence*:—Fairly common in the *Catapsydrax stainforthi* Zone but rather scarce in the *Globigerinatella insueta* Zone (*s.l.*), and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Bolivina caudriae* Cushman and Renz**

*Bolivina caudriae* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 19, pl. 3, figs. 13-14.

*Remarks*:—This species appears to be closely related to *Bolivina arta* Macfadyen but is generally smaller and with a less compressed test. Also this species has curved sutures.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625884.

*Occurrence*:—Only observed in isolated samples from the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

***Bolivina imporeata* Cushman and Renz**

*Bolivina floridana* Cushman var. *imporeata* Cushman and Renz, 1944, Cushman Lab. Foram. Res., Contr., vol. 20, pt. 3, p. 78.

*Bolivina imporeata* Cushman and Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 118, pl. VII, figs. 3a-b.

*Remarks*:—Originally described as a variety of *Bolivina floridana* Cushman, but this form appears to be distinctly different from this species considering the more elongate nature of its test and chambers. Some specimens show elongate gently tapering tests with the last two chambers rather inflated.

*Hypotype*:—From sample, No. RM 19320, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625886.

*Occurrence*:—Occurs throughout the Pozón formation and often especially abundant in *Globorotalia fohsi* "Zone" (*s.l.*) but becomes scarce in the *Globigerina bulloides* Zone, Pozón formation.

***Bolivina isidroensis* Cushman and Renz**

*Bolivina isidroensis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 17, pl. 3, fig. 8.

*Hypotype*:—From sample, No. RM 19320, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625888.

*Occurrence*:—Common in the *Globorotalia fohsi* "Zone" (*s.l.*), *Globorotalia mayeri* Zone (*s.l.*), and *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone but becomes scarce in the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Bolivina marginata multicostata* Cushman**

*Bolivina marginata* Cushman var. *multicostata* Cushman, 1930, Florida Geol. Surv., Bull., pt. 6, pl. 8, figs. 13-14 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19784, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625890.

*Occurrence*:—Only observed by the writer in the upper part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and in the lower part of the *Sphaeroidinella seminulina* Zone, Pozón formation. Renz (1948), however, recorded this species as occurring nearly throughout all of the upper Tocuyo and Pozón formations.

***Bolivina pisciformis* Galloway and Morrey**

Pl. 6, fig. 21

*Bolivina pisciformis* Galloway and Morrey, 1929, Bull. Amer. Pal., vol. 15, No. 55, p. 36, pl. 5, fig. 10.

*Remarks*:—This species has a broad test in which the marginal ends of the chambers are strongly directed to the initial end. This species resembles *Bolivina alazanensis* Cushman but has narrower chambers.

It differs from *Bolivina alata* (Seguenza), with which it has been confused, by having broader later chambers.

*Hypotype*:—From sample, No. RM 19320, auger line near Pozón, eastern Falcón; Plate 7, figure 21. deposited in U.S.N.M. collection, No. 625892.

*Occurrence*:—This species seems to be restricted to, and is fairly common in, the *Catapsydrax stainforthi* Zone, *Globigerina tella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Bolivina pozonensis* Cushman and Renz**

*Bolivina pozonensis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 16, pl. 3, fig. 6.

*Remarks*:—This species is distinct from *Bolivina mantaensis* Cushman, largely because of this species' "coarsely perforate wall structure". The fine longitudinal costae mentioned by Cushman and Renz in their type description seem to be a variable feature. In some specimens these costae are pronounced; in others, costae can only be observed when the specimen is moistened.

*Hypotype*:—From sample, No. RM 19460, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625894.

*Occurrence*:—Fairly common in the *Globorotalia fohsi robusta* Zone, *Globigerina mayeri* Zone (*s.l.*) and in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone. It becomes scarce in the lower part of the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Bolivina pseudobeyrichi* Cushman**

Pl. 6, fig. 22

*Non Bolivina beyrichi* Reuss var. *alata* (Seguenza), Brady, 1884, Challenger Exped. Rept., Zool., vol. 9, p. 422, pl. 53, figs. 2-4.

*Bolivina beyrichi* var. *alata* Cushman (*non* Seguenza), 1911, U.S. Nat. Mus., Bull. 71, pt. 2, p. 35, text-Fig. 57, (*fide* Drooger, 1953).

*Bolivina pseudobeyrichi* Cushman, 1937, Contr. Cushman Lab. Foram. Res., Spec. Pub. 9, p. 139, pl. 19, figs. 4, 5 (*fide* Drooger, 1953).

*Bolivina alata* Renz (*non* Seguenza), 1948, Geol. Soc. Amer., Mem. 32, p. 116, pl. VII, fig. 26; pl. XII, figs. 12 a-b.

*Remarks*:—This species appears to be related to *Bolivina beyrichi* Reuss but possesses a more-or-less continuous keel of clear shell material between the peripheral spines. Drooger (1953, p. 131) pointed out that most West Indian references of *Bolivina alata* are different from Seguenza's type.

*Hypotype*:—From sample, No. RM 19400, auger line near Pozón, eastern Falcón; Plate 6, figure 22, deposited in U.S.N.M. collection, No. 625895.

*Occurrence*:—Occurs, but is scarce, in the *Globorotalia fohsi* "Zone" (*s.l.*) and in the lower part of the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

***Bolivina simplex* Cushman and Renz**

*Bolivina interjuncta* Cushman var. *simplex* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt 1, p. 20, pl. 3, fig. 15.

*Bolivina simplex* Cushman and Renz, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 119, pl. VII, figs. 4a-b.

*Non Bolivina simplex* Phleger and Parker, 1951, Geol. Soc. Amer., Mem. 46, pt. 2, p. 14, pl. 7, figs. 4-6.

*Remarks:*—Renz elevated the Cushman and Renz variety to specific rank in 1948. *Bolivina simplex* Phleger and Parker, 1951 is distinctly different from the strongly costate species of Cushman and Renz.

*Hypotype:*—From sample, No. RM 19789, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625897.

*Occurrence:*—First observed, and scarce, in the *Globorotalia fohsi fohsi* Zone, but becomes abundant in the upper part of *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and common in the overlying *Sphaeroidinella seminulina* Zone, Pozón formation. The distribution and abundance of this form seems to be closely controlled by ecological conditions since it occurs in floods in isolated samples but may be scarce in stratigraphically adjacent samples.

***Bolivina suteri* Cushman and Renz**

*Bolivina suteri* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 18, pl. 3, fig. 9.

*Remarks:*—A distinctive form with highly inflated chambers and incised sutures.

*Hypotype:*—From sample, No. RM 19450, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625899.

*Occurrence:*—Only observed in a few samples from the *Globorotalia fohsi robusta* Zone and *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

***Bolivina thalmanii* Renz**

*Bolivina thalmanii* Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 120, pl. XII, figs. 13a-c.

*Remarks:*—This species is quite distinctive mainly because of its coarse reticulate ornamentation, but it may be related to *Bolivina cancellata* Bermudez.

*Hypotype:*—From sample, No. RM 19536, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625901.

*Occurrence*:—Observed only in isolated samples from the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

Genus **BULIMINA** d'Orbigny, 1826

***Bulimina alazanensis* Cushman**

*Bulimina alazanensis* Cushman, 1927, Jour. Pal., vol. 1, p. 161, pl. 25, fig. 4 (*fide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19445, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625903.

*Occurrence*:—Occurs, but is scarce, in the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta* Zone (*s.l.*) but becomes common to abundant in the *Globorotalia fohsi lobata* Zone, the *Globorotalia fohsi robusta* Zone, and in the *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations. Scarce in sediments younger than the latter zone.

***Bulimina alligata* (Cushman and Laiming)**

Pl. 6, fig. 23

*Bulimina inflata* Seguenza var. *alligata* Cushman and Laiming, 1931, Jour. Pal., vol. 5, No. 2, p. 107, pl. 11, figs. 17a-b (*fide* Ellis and Messina, 1940 *et seq.*).

*Remarks*:—The writer considers that this form is distinct from *Bulimina inflata*, and accordingly it is elevated to specific rank. The costae are fairly weak but arranged generally in longitudinal lines. The chambers are axially longer than in *Bulimina inflata*, especially the last chamber, but the spines are not so well pronounced. The aperture is also rather more elongate than in *Bulimina inflata* Seguenza.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 6, figure 23, deposited in U.S.N.M. collection, No. 625905.

*Occurrence*:—Seems to be restricted to the upper Tocuyo formation and the Pozón formation below the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone.

***Bulimina falconensis* Renz**

*Bulimina falconensis* Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 121, pl. VI, figs. 15a-b.

*Remarks*:—Renz (1948) considered his species to be identical

with *Bulimina buchiana* Cushman and Ponton, 1932. However, the name *Bulimina buchiana* was used by D'Orbigny in 1846; hence *Bulimina buchiana* Cushman and Ponton, 1932 is a homonym of *Bulimina buchiana* d'Orbigny, 1846 and, therefore, invalid.

*Bulimina falconensis* is probably closely related to *Bulimina sculptis* Cushman, 1923 (*non* Renz, 1942) but can be distinguished from the latter species by the less regular costae some of which do not reach the initial end of the test. The chambers of *Bulimina sculptis* Cushman are more inflated than in *Bulimina falconensis*.

*Hypotype*:—From sample, No. RM 19460, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625907.

*Occurrence*:—Scarce in the *Globorotalia fohsi lobata* Zone but becomes fairly frequent in the *Globorotalia fohsi robusta* Zone and in the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone, Pozón formation.

#### ***Bulimina inflata* Seguenza**

*Bulimina inflata* Seguenza, 1862, Accad. Gioenia Sci. Nat., Atti., ser. 2, vol. 18, p. 109, pl. 1, fig. 10 (*fide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19300, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625909.

*Occurrence*:—Fairly common throughout the upper Tocuyo and Pozón formations, although it only occurs sporadically in the uppermost part of the *Sphaeroidinella seminulina* Zone.

#### ***Bulimina pupoides* d'Orbigny**

*Bulimina pupoides* d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne (Autriche), p. 185, pl. 11, figs. 11-12. (*Fide* Ellis and Messina, 1940, *et seq.*).

*Remarks*:—The form is rather variable: in some forms the last chamber embraces most of the earlier test; in others as many as three or four earlier whorls are visible. However, all gradations exist between these two extremes. Some forms have a fairly well-developed basal projection.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625911.

*Occurrence*:—This species appears to have a similar stratigraphical and ecological distribution to *Bulimina* (*Globobulimina*) *perversa* Cushman.

Subgenus **GLOBOBULIMINA** Cushman, 1927**Bulimina (Globobulimina) perversa** Cushman

*Bulimina pyrula* d'Orbigny var. *perversa* Cushman, 1921, U.S. Nat. Mus., Bull. 100, vol. 4, p. 163, text-figs 2a-c.

*Bulimina (Globobulimina) perversa* Cushman, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 122, pl. VI, fig. 16.

*Remarks:*—This form shows rather variable morphology: some specimens tend to be rather more elongate, others are almost as broad as long, but all transitions occur.

*Hypotype:*—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625913.

*Occurrence:*—This form seems to be strongly influenced by ecological conditions since its occurrence is often sporadic and variable, often associated with rather poor mainly "arenaceous faunas". Generally scarce in all zones below the middle part of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

Genus **BULIMINELLA** Cushman, 1911**Buliminella basistriata nuda** Howe and Wallace

*Buliminella basistriata* Cushman and Jarvis var. *nuda* Howe and Wallace, 1932, Louisiana Dept. Cons. Geol. Bull., No. 2, p. 60, pl. 11, fig. 4 (*vide* Renz, 1948).

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625915.

*Occurrence:*—Occurs in variable abundance throughout the upper Tocuyo and Pozón formations. It is especially abundant in the lower part of the *Sphaeroidinella seminulina* Zone. It is strongly influenced by ecological conditions and often occurs in floods but may become scarce in samples only a few feet stratigraphically higher or lower.

Genus **ENTOSOLENIA** Ehrenberg, 1848**Entosolenia marginata** (Walker and Boys)

*Serpula (Lagena) marginata* Walker and Boys, 1784, Test. Min., p. 2, pl. 1, fig. 7 (*vide* Beckmann, 1953).

*Lagena marginata* (Walker and Boys), Beckman, 1953, Eclog. Geol. Helv., vol. 46, No. 2, p. 358, pl. 20, fig. 5.

*Remarks:*—This form shows the presence of a distinct internal tube. Test is rather compressed with a peripheral flange of clear

shell material. Aperture at the end of a distinct and fairly long neck which is elliptical in cross-section.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625917.

*Occurrence*:—Ubiquitous and fairly common in all zones below the base of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

Genus **REUSSELLA** Galloway, 1933

**Reussella spinulosa** (Reuss)

Pl. 7, fig. 24

*Ferncuilina spinulosa* Reuss, 1859, Akad. Wiss. Wien Denkschr., vol. 1, p. 374, fig. 12 (*vide* Ellis and Messins, 1940 *et seq.*).

*Reussella spinulosa* (Reuss), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 156, pl. VII, figs. 16-17.

*Hypotype*:—From sample, No. RM 20131, auger line near Pozón, eastern Falcón; Plate 7, figure 24, deposited in U.S.N.M. collection, No. 625919.

*Occurrence*:—Renz recorded this species as being restricted to his *Elphidium poeyanum*-*Reussella spinulosa* Zonule (= part of *Globigerina bulloides* Zone, Pozón formation), but the present writer has observed isolated specimens stratigraphically lower and associated with *Vaginulinopsis superbus*. It is closely associated with some species of *Rotalia*, and its occurrence is strongly governed by ecological conditions. It may be common in a particular sample but may be rare or absent in stratigraphically adjacent samples. It has been observed in varying frequency from the *Sphaeroidinella seminulina* Zone and *Globigerina bulloides* Zone, Pozón formation.

Genus **SIPHOGENERINA** Schlumberger, 1883

**Siphogenerina kugleri** Cushman and Renz

*Siphogenerina kugleri* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 22, pl. 3, figs. 21-22.

*Hypotype*:—From sample, No. RM 19282, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625921.

*Occurrence*:—Scarce, only observed in samples from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone and *Globorotalia fohsi fohsi* Zone, Pozón formation.

***Siphogenerina lamellata* Cushman**

*Siphogenerina lamellata* Cushman, 1918, U.S. Geol. Surv., Bull. 676, p. 55, pl. 12, fig. 3.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625923.

*Occurrence*:—Common or abundant in all zones of the upper Tocuyo and Pozón formations below the *Sphaeroidinella seminulina* Zone. Occasional specimens have been observed in the middle to lower part of this latter zone. The disappearance of this species may be due to ecological rather than stratigraphical reasons.

***Siphogenerina multicostata* Cushman and Jarvis**

*Siphogenerina multicostata* Cushman and Jarvis, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 14, pl. 3, fig. 6 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625925.

*Occurrence*:—Generally scarce but observed in samples from the *Globigerinatella insueta* Zone (*s.l.*) and in the *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Siphogenerina senni* Cushman and Renz**

*Siphogenerina senni* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 22, pl. 3, figs. 21-22.

*Siphogenerina cummingsi* Galloway and Heminway, 1941, New York Acad. Sci., vol. 3, pt. 4, p. 433, pl. 34, figs. 6-7.

*Siphogenerina yumuriana* Palmer, 1941, Soc. cubana hist. nat., Mem., vol. 15, No. 2, p. 185, pl. 15, figs. 3-4.

*Siphogenerina senni* Cushman and Renz, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 165, pl. VII, figs. 29a-b, 30.

*Hypotype*:—From sample, No. RM 19116, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625927.

*Occurrence*:—Rather scarce, but observed in samples from the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*), and in the *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

***Siphogenerina transversa* Cushman**

Pl. 6, fig. 25

*Siphogenerina raphanus* (Parker and Jones) var. *transversus* Cushman, 1918, U.S. Nat. Mus., Bull. 103, p. 64, pl. 22, fig. 8 (*vide* Ellis and Messina, 1940 *et seq.*).

*Siphogenerina transversa* Cushman, Cushman and Parker, 1931, Cushman Lab. Foram. Res., Contr., vol. 7, p. 10, pl. 2, figs. 5, 6 (*vide* Renz, 1948).  
*Siphogenerina transversa* Cushman, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 166, pl. VII, figs. 27, 28, pl. XII, fig. 9.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; Plate 6, fig. 25, deposited in U.S.N.M. collection, No. 625929.

*Occurrence*:—Renz used this species as the zonal index for his *Siphogenerina transversa* Zone. It does not range higher than the middle part of the *Globorotalia fohsi fohsi* Zone. Common to abundant in the *Catapsydrax stainforthi* Zone, and in the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations, but becomes comparatively scarce thereafter. Since there is no apparent change of facies over the interval covering the disappearance of this form, it is considered that its disappearance is due to stratigraphical reasons alone.

Genus **STILOSTOMELLA** Guppy, 1894

**Stilostomella verneuili** (d'Orbigny)

*Dentalina verneuili* d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne (Autriche), p. 48, pl. 2, figs. 7-8. (*Fide* Ellis and Messina, 1940 *et seq.*).

*Ellipsonodosaria? verneuili* (d'Orbigny), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 131, pl. VIII, fig. 3-5.

*Remarks*:—The specimens observed in the Pozón-El Mene Road section appear to be typical for the species. Stainforth (1952b) specifically mentions this species as included in the genus *Siphonodosaria* and gave cogent reasons why *Ellipsonodosaria* should be placed in synonymy with *Nodosarella*. The latter genus, however, has a crescentic aperture whilst the species "*verneuili*" possesses a round aperture with a short collar-like neck. Later, Stainforth (1952c) pointed out that the genus *Stilostomella* has priority over the genus *Siphonodosaria*.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625931.

*Occurrence*:—Common in all zones of the upper Tocuyo and Pozón formations, below the base of the *Sphaeroidinella seminulina* Zone.

Genus **UVIGERINA** d'Orbigny, 1826**Uvigerina auberiana attenuata** Cushman and Renz

*Uvigerina auberiana* d'Orbigny var. *attenuata* Cushman and Renz, Cushman Lab. Foram. Res., Contr., vol. 17, p. 21, pl. 3, fig. 17.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625932.

*Occurrence*:—Generally rather scarce in all zones of the upper Tocuyo and Pozón formations below the *Globorotalia menardii* *menardii*/*Globigerina nepenthes* Zone.

**Uvigerina capayana** Hedberg

*Uvigerina pygmaea* d'Orbigny var. *capayana* Hedberg, 1937, Jour. Pal., vol. 11, p. 677, pl. 91, fig. 19.

*Uvigerina capayana* Hedberg, Cushman and Edwards, 1938, Cushman Lab. Foram. Res., Contr., vol. 14, p. 80, pl. 14, fig. 1 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625934.

*Occurrence*:—Generally common in all zones of the upper Tocuyo and Pozón formations below the *Globorotalia menardii* *menardii*/*Globigerina nepenthes* Zone but scarce in this latter zone.

**Uvigerina carapitana** Hedberg

*Uvigerina carapitana* Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 677, pl. 91, fig. 20.

*Hypotype*:—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625936.

*Occurrence*:—Generally common in all zones of the upper Tocuyo and Pozón formations below the lower to middle part of the *Sphaeroidinella seminulina* Zone.

**Uvigerina cubana** Palmer and Bermudez

Pl. 8, fig. 26

*Uvigerina cubana* Palmer and Bermudez, 1936, Soc. cubana hist. nat., Mem., vol. 10, p. 292, pl. 17, figs. 5-6.

*Remarks*:—This species appears to be closely related to *Uvigerina gallowayi* Cushman, 1926 and possibly to *Uvigerina barbatula* Macfadyen.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 8, fig. 26, deposited in U.S.N.M. collection, No. 625938.

*Occurrence*:—Scarce and only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

***Uvigerina gallowayi basicordata* Cushman and Renz**

*Uvigerina gallowayi* Cushman var. *basicordata* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 21, pl. 3, fig. 18.

*Hypotype*:—From sample, No. RM 19283, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625940.

*Occurrence*:—Only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

***Uvigerina* cf. *hannai* Kleinpell**

cf. *Uvigerina californica* Hanna (*non* Cushman), 1928, Bull. Amer. Assoc. Petr. Geol., vol. 12, pl. 9, fig. 3 (*vide* Kleinpell, 1938).

cf. *Uvigerina hannai* Kleinpell, 1938, Amer. Assoc. Petr. Geol., Spec. Publ., p. 294.

*Uvigerina* cf. *hannai* Kleinpell, Renz, 1948 (*pars*), Geol. Soc. Amer., Mem. 32, p. 174, pl. XII, figs. 16a-b (not fig. 17).

*Remarks*:—The writer's specimens do not show the costae over the earlier chambers as shown by Renz (1948, pl. XII, fig. 17) and as mentioned by Kleinpell (1938, p. 294). However, the specimens appear to be identical to some figured by Renz (1948, pl. XII, figs. 16a-b) and only show the slightest trace of rather irregular fine costae when the specimens are moistened. The writer's specimens are only tentatively assigned to Kleinpell's species.

*Hypotype*:—From sample, No. RM 19405, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625942.

*Occurrence*:—Scarce in the *Globorotalia fohsi fohsi* Zone but becomes common in the *Globorotalia fohsi lobata* Zone, *Globorotalia fohsi robusta* Zone and also in the *Globorotalia mayeri* Zone (*s.l.*). Only occasional specimens have been seen in the lower part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Uvigerina isidroensis* Cushman and Renz**

*Uvigerina isidroensis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 20, pl. 3, fig. 16.

*Uvigerina hispidocostata* Cushman and Todd, 1945, Cushman Lab. Foram. Res., Spec. Pub. 15, p. 51, pl. 7, figs. 27, 31 (*vide* Ellis and Messina, 1940 *et seq.*).

*Remarks:*—This form shows considerable variation. The typical form is strongly costate with the costae not quite covering the last chamber; however, in other forms the costae are wanting on the last chamber but small poorly formed pustules may be present. All transitions between forms with costae over the complete test and forms with pustules over the last chamber are present. The number of chambers is also variable. Usually about 4-5 whorls are present but sometimes as many as seven are observed with the last chamber becoming rather pointed, and the aperture centrally placed.

*Hypotype:*—From sample, No. RM 19282, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625944.

*Occurrence:*—Ubiquitous but varies greatly in frequency. Generally rather scarce in the mainly planktonic facies of the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta* Zone (*s.l.*), and in the *Globorotalia mayeri* Zone (*s.l.*). Often common or abundant in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, and in the *Sphaeroidinella seminulina* Zone but becomes scarce in the overlying *Globigerina bulloides* Zone, Tocuyo and Pozón formations. The distribution of this form is strongly dependent on ecological conditions, some samples from the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and *Sphaeroidinella seminulina* Zone have over 95% of the total fauna present as this species. It is often associated with *Bolivina imporcata* and *Bolivina simplex*.

***Uvigerina rustica* Cushman and Edwards**

*Uvigerina rustica* Cushman and Edwards, 1938, Cushman Lab. Foram. Res., Contr., vol. 14, p. 83, pl. 14, fig. 6 (*vide* Renz, 1948).

*Hypotype:*—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625946.

*Occurrence:*—Generally rather scarce in all zones of the upper Tocuyo and Pozón formations below the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone.

Genus **VIRGULINA** d'Orbigny, 1826

***Virgulina pontoni* Cushman**

*Virgulina pontoni* Cushman, 1932, Cushman Lab. Foram. Res., Contr., vol. 8, p. 17, pl. 3, fig. 7 (*vide* Ellis and Messina, 1940 *et seq.*).

*Virgulina pontoni* Cushman, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 178, pl. VI, fig. 18.

*Hypotype*:—From sample, No. RM 19405, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625948.

*Occurrence*:—Fairly common in the *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

#### Family ROTALIIDAE

Genus **CANCERIS** Montfort, 1808

##### ***Canceris panamensis*** Natland

*Canceris panamensis* Natland, 1938, Scripps Inst. Oceanog., Bull. Tech. Ser., vol. 4, No. 5, p. 148, pl. 6, figs. 1a-c (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625950.

*Occurrence*:—Common in all zones of the upper Tocuyo and Pozón formations below the *Globigerina bulloides* Zone.

##### ***Canceris sagra*** (d'Orbigny)

*Rotalia sagra* d'Orbigny, 1839, "Foraminifères", in de la Sagra, Histoire physique, politique et naturelle de l'île de Cuba, p. 77, pl. 5, figs. 13-15 (*vide* Ellis and Messina, 1940 *et seq.*).

*Canceris sagra* (d'Orbigny), Cushman, 1931, U.S. Nat. Mus., Bull. 104, pt. 8, p. 74, pl. 15, fig. 2 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 19340, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625952.

*Occurrence*:—Occurs rarely and only sporadically in the *Globorotalia fohsi* "Zone" (*s.l.*) and in the *Globorotalia mayeri* Zone (*s.l.*) but becomes relatively common in the upper part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and in *Sphaeroidinella seminulina* Zone; scarce in the *Globigerina bulloides* Zone, Pozón formation.

Genus **EPONIDES** Montfort, 1808

##### ***Eponides crebbsi*** Hedberg

*Eponides crebbsi* Hedberg, 1937, Jour. Pal., vol. 11, p. 679, pl. 92, figs. 1a-c.

*Remarks*:—The sinuous umbilical sutures makes this species distinctive.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625954.

*Occurrence*:—Common or fairly common in the upper part of the Tocuyo formation and in the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), but only occurs in isolated samples from the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Eponides parantillarum*** Galloway and Heminway

*Eponides parantillarum* Galloway and Heminway, 1941, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 374, pl. 18 figs. 1a-c.

*Remarks*:—This form appears to be closely related to *Eponides antillarum* (d'Orbigny).

*Hypotype*:—From sample, No. RM 19849, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625956.

*Occurrence*:—Fairly common in, and apparently restricted to, the middle to upper part of the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Eponides umbonatus ecuadorensis*** (Galloway and Morrey)

*Rotalia ecuadorensis* Galloway and Morrey, 1929, Bull. Amer. Pal., vol. 15, No. 55, p. 26, pl. 3, figs. 13a-c

*Eponides umbonatus* (Reuss) var. *ecuadorensis* (Galloway and Morrey), Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 679, pl. 91, fig. 22.

*Remarks*:—This form shows a strongly vaulted umbilical side and a convex spiral side; sutures not depressed, radial on the spiral side and slightly sinuous umbilically. Chambers, as seen from spiral side, are rather narrow but elongate tangentially. Umbilicus closed, aperture interiomarginal, sutural, rather short, midway between the keeled periphery and the umbilicus. The subspecies is distinguished from the parent species by virtue of the slightly sinuous umbilical sutures and umbilical plug.

This form shows a combination of many of the characters used by Brotzen (1942) to differentiate *Gyroidina* and *Eponides*.

*Hypotype*:—From sample, No. RM 19320, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625958.

*Occurrence*:—Rather scarce in the upper part of the Tocuyo formation and in the *Globigerinatella insueta* Zone (*s.l.*) but becomes common or even abundant in samples from the *Globorotalia*

*fohsi* "Zone" (*s.l.*), *Globorotalia mayeri* Zone (*s.l.*), and *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone. Becomes rare and only occurs sporadically in the lower part of the *Sphaeroidinella seminulina* Zone, Pozón formation.

Genus **GYROIDINA** d'Orbigny, 1826

**Gyroidina parva** Cushman and Renz

*Gyroidina parva* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 23, pl. 4, fig. 2.

*Hypotype*:—From sample, No. RM 19340, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625960.

*Occurrence*:—Occurs throughout the upper part of the Tocuyo and Pozón formations. Usually rather scarce below the *Globorotalia fohsi fohsi* Zone and above the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, but common or abundant especially in the *Globorotalia fohsi robusta* Zone and *Globorotalia mayeri* Zone (*s.l.*).

Genus **GYROIDINOIDES** Brotzen, 1942

**Gyroidinoides altiformis** (R. E. and K. C. Stewart) Pl. 7, figs. 27a-c

*Gyroidina soldanii* d'Orbigny var. *altiformis* R. E. and K. C. Stewart, 1930, Jour. Pal., vol. 4, p. 67, pl. 9, fig. 2.

*Gyroidinoides soldanii* (d'Orbigny) var. *altiformis* (R. E. and K. C. Stewart), Renz, 1948, Geol. Soc. Amer., Mem 32, p. 140, pl. VIII, figs. 13a-c.

*Remarks*:—This form is different from D'Orbigny's illustrations of the species "*soldanii*" and from *Gyroidinoides* cf. *zelandica* Finlay. The sutures of the spiral side are distinct and the spiral suture well marked throughout. Sutures between the chambers are fairly deeply incised. The writer considers that this form is worthy of specific status and it is elevated accordingly.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 7, figs. 27a-c, deposited in U.S.N.M. collection, No. 625962.

*Occurrence*:—Fairly common in all zones of the Pozón formation below the base of the *Sphaeroidinella seminulina* Zone and in the upper part of the Tocuyo formation. Occasional specimens have been observed in samples from the upper part of the *Sphaeroidinella seminulina* Zone. The disappearance of this form in eastern

Falcón seems to be due to ecological rather than stratigraphical reasons.

**Gyroidinoides byramensis campester** (Palmer and Bermudez)

*Eponides byramensis* (Cushman) var. *campester* Palmer and Bermudez, 1941, Soc. cubana hist. nat., Mem., vol. 15, No. 2, p. 192.

*Gyroidinoides byramensis* (Cushman) var. *campester* (Palmer and Bermudez), Renz, 1948, Geol. Soc. Amer., Mem. 32, pp. 139-140, pl. VIII, figs. 15a-b; pl. IX, fig. 1.

*Eponides campester* Palmer and Bermudez, Bermudez, 1949, Cushman Lab. Foram. Res., Special Pub. 25, p. 245, pl. 16, figs. 40-42.

*Remarks:*—The present writer agrees with Renz (1948) that this species is best placed within the genus *Gyroidinoides* Brotzen, 1942 on account of the distinctive open umbilicus. Faint traces of an apertural lip have been observed which serve to substantiate the generic allocation. The subspecies differs from the parent species in having slightly limbate sutures and a less vaulted umbilical surface.

*Hypotype:*—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625964.

*Occurrence:*—Generally scarce but has been observed in samples from the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*), and *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

**Gyroidinoides planulata** (Cushman and Renz)

*Gyroidina planulata* Cushman and Renz, 1941, Cushman Lab. Foram. Res., vol. 17, pt. 1, p. 23, pl. 4, fig. 1.

*Gyroidinoides planulata* (Cushman and Renz), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 140, pl. VIII, figs. 11a-c.

*Hypotype:*—From sample, No. RM 19282, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection No. 625966.

*Occurrence:*—Scarce, only observed in the *Globigerinatella insueta*/*Globigerinoides bisphérica* Subzone, *Globorotalia fohsi barisanensis* Zone, and *Globorotalia fohsi fohsi* Zone, Pozón formation.

**Gyroidinoides venezuelana** Renz

*Gyroidinoides venezuelana* Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 141, p. XII, figs. 21a-c.

*Remarks:*—Renz considers his species related to *Gyroidina laevigata* d'Orbigny but distinguished from D'Orbigny's species by the more sharply edged periphery and less inflated chambers. Renz further stated that his species is also related to *Gyroidinoides planulata* Cushman and Renz which, however, has a rounded periphery.

*Hypotype:*—From sample No. RM 19305, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625968.

*Occurrence:*—Scarce in the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations but becomes fairly common in the *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*) and rather scarce in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone and only observed in isolated samples from the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Gyroidinoides cf. zelandica* (Finlay)**

Pl. 8, figs. 28a-c

cf. *Gyroidina zelandica* Finlay, 1939, Roy. Soc. New Zealand, Trans. Proc., vol. 69, pt. 3, p. 323, pl. 28, figs. 138-140 (*vide* Ellis and Messina, 1940 *et seq.*).

*Gyroidina cf. soldanii* Galloway and Heminway (*non* d'Orbigny), 1941, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Islands, vol. 3, pt. 4 p. 377, pl. 15, figs. 7a-c.

*Gyroidinoides cf. soldanii* Renz (*non* d'Orbigny), 1948, Geol. Soc. Amer. Mem. 32, p. 140, pl. VIII, figs. 14a-c.

*Remarks:*—Renz (1948) tentatively referred some species identical to those seen by the writer to *Gyroidinoides soldanii* (d'Orbigny). However, D'Orbigny's figure of *Gyroidina soldanii* shows radial sutures on the spiral side and a well-marked spiral suture throughout; furthermore the umbilical side is not highly vaulted.

The specimens seen in the Tocuyo and Pozón formations agree closely with Finlay's species although the eastern Falcón specimens have a slightly wider umbilicus. Cushman and Stainforth (1948) figured a form as *Gyroidina girardana* (Reuss) var. *perampla* which also appears to be close to both Finlay's *G. zelandica* and the writer's specimens. However, since Finlay's species has priority and the eastern Falcón material resembles both *G. girardana* var. *perampla* and *G. zelandica* equally closely, they are tentatively

referred to the latter species. Finlay (1939) considered his species as being related to *Gyroidinoides altiformis* (R. E. and K. C. Stewart) and the specimens seen here also show a similar relationship.

*Hypotype*:—From sample, No. RM 19283, auger line near Pozón, eastern Falcón; Plate 8, figures 28a-c, deposited in U.S.N.M. collection, No. 625970.

*Occurrence*:—Scarce, only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi fohsi* Zone, Pozón formation.

#### Genus **PULVINULINELLA** Cushman, 1926

##### **Pulvinulinella culter** (Parker and Jones)

*Planorbulina fareta* (Fichtel and Moll) var. *ungeriana* (d'Orbigny) subvar. *culter* Parker and Jones, 1865, Roy. Soc. London, Phil. Trans., vol. 155, p. 382, pl. 9, figs. 1a-b (*vide* Cushman, 1929).

*Pulvinulinella culter* (Parker and Jones), Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 100, pl. 14, fig. 13.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625972.

*Occurrence*:—Scarce and only observed in isolated samples from the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation, and the lower part of the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, Pozón formation.

##### **Pulvinulinella jarvisi** Cushman and Renz

*Pulvinulinella jarvisi* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 24, pl. 4, fig. 4.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625974.

*Occurrence*:—Observed only in samples from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone and *Globorotalia fohsi* "Zone" (*s.l.*), Pozón formation.

#### Genus **ROTALIA** Lamarck, 1804

##### **Rotalia beccarii** (Linné)

*Nautilus beccarii* Linné, 1767, Systema Naturae, 12th ed., vol. 1, p. 1162. (*Fide* Ellis and Messina, 1940 et seq.).

*Rotalia beccarii* (Linné), Cushman, 1928, Cushman Lab. Foram. Res., Contr., vol. 4, p. 103, pl. 15 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 20131, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625976.

*Occurrence*:—Only observed by the writer in the middle to upper part of the *Sphaeroidinella seminulina* Zone and in the *Globigerina bulloides* Zone, Pozón formation. It becomes common in the overlying Ojo de Agua formation.

Genus **SIPHONINA** Reuss, 1850

**Siphonina pozonensis** Cushman and Renz

*Siphonina pozonensis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 24, pl. 4, fig. 3.

*Hypotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625978.

*Occurrence*:—Occurs in varying frequency in the upper part of the Tocuyo formation and throughout the Pozón formation below the *Globigerina bulloides* Zone. Most frequent in the *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*) but becomes scarce in the *Sphaeroidinella seminulina* Zone.

Genus **VALVULINERIA** Cushman, 1926

**Valvulineria herricki** (Hadley)

Pl. 8, figs. 29a-b

*Cibicorbis herricki* Hadley, 1934, Bull. Amer. Pal., vol. 20, p. 26, pl. 5, figs. 1-3 (*vide* Renz, 1948).

*Cibicides kugleri* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 27, pl. 4, fig. 11.

*Valvulineria herricki* (Hadley), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 177, pl. VIII, figs. 10a-c.

*Hypotype*:—From sample, No. RM 19405, auger line near Pozón, eastern Falcón; Plate 8, figures 29a-b, deposited in U.S.N.M. collection, No. 625980.

*Occurrence*:—Renz (1948) used the partial occurrence of this species to define his *Valvulineria herricki* Zone. The present writer has observed specimens in the uppermost part of the *Globorotalia fohsi fohsi* Zone, *Globorotalia fohsi lobata* Zone, *Globorotalia fohsi robusta* Zone, and *Globorotalia mayeri* Zone (*s.l.*), Pozón formation. Some specimens have been noted associated with *Marginulinopsis basispinosus*.

The distribution of this form seems to be strongly influenced by ecological conditions since it is most frequent in sample con-

taining an appreciable planktonic component and absent in samples with a rich *Uvigerina isidroensis-Bolivina imporcata-Bolivina simplex* assemblage.

**Valvulineria inaequalis lobata** Cushman and Renz

*Valvulineria inaequalis* (d'Orbigny) var. *lobata* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 23, pl. 3, fig. 24.

*Hypotype*:—From sample, No. 19180, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625982.

*Occurrence*:—Scarce, only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), and from the *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

Family AMPHISTEGINIDAE

Genus AMPHISTEGINA d'Orbigny, 1826

**Amphistegina cf. lessonii** d'Orbigny

cf. *Amphistegina lessonii* d'Orbigny, 1826, Ann. Sci. Nat., Paris, sér. 1, vol. 7, p. 304, Modèles No 98 (*vide* Renz, 1948).

*Remarks*:—Most of the specimens present in the Pozón section are broken and abraded.

*Hypotype*:—From sample, No. RM 19888, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625983.

*Occurrence*:—Occurs mainly in the uppermost part of the Pozón formation (Huso Clay member).

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

**Cassidulina carapitana** Hedberg

*Cassidulina carapitana* Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 680, pl. 96, figs. 6a-b.

*Remarks*:—Hedberg (1937, p. 680) remarked that his species belongs to the group of *Cassidulina laevigata* d'Orbigny but can be distinguished from this species since the sutures of *Cassidulina carapitana* are more sharply curved in the umbonal areas than in D'Orbigny's species.

*Hypotype*:—From sample, No. RM 19283, auger line near

Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625985.

*Occurrence*:—Common in all zones of the upper Tocuyo and Pozón formations below the middle part of the *Sphaeroidinella seminulina* Zone. The disappearance of this form seems to be due to ecological rather than stratigraphical reasons.

***Cassidulina crassa* d'Orbigny**

*Cassidulina crassa* d'Orbigny, 1839, Voyage dans l'Amérique Méridionale; "Foraminifères", vol. 5, pt. 5, p. 56, pl. 7, figs. 18-20. (*Fide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625987.

*Occurrence*:—Common in all zones of the Pozón formation below the middle to upper part of the *Sphaeroidinella seminulina* Zone but rather scarce in the Tocuyo formation.

***Cassidulina delicata* Cushman**

*Cassidulina delicata* Cushman, 1927, California Univ., Scripps Inst. Oceanog., Bull. Tech. ser., vol. 1, p. 168, pl. 6, fig. 5 (*fide* Renz 1948).

*Hypotype*:—From sample, No. 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625989.

*Occurrence*:—Scarce and only observed in the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone and *Globorotalia fohsi barisanensis* Zone, Pozón formation.

***Cassidulina laevigata* d'Orbigny**

*Cassidulina laevigata* d'Orbigny, 1826, Ann Sci. Nat., Paris, sér. 1, vol. 7, p. 282, pl. 15, figs. 4-5 (*fide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625991.

*Occurrence*:—Fairly common in all zones of the Pozón formation below the *Globigerina bulloides* Zone and in the upper part of the Tocuyo formation; especially common in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone.

***Cassidulina subglobosa* Brady**

*Cassidulina subglobosa* Brady, 1881, Roy. Micr. Soc., Quart. Jour., new ser., vol. 21, p. 60 (*fide* Ellis and Messina, 1940 *et seq.*).

*Remarks*:—The aperture of this form is normal to the axis of coiling.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625993.

*Occurrence*:—Ubiquitous although rather scarce. Ranges throughout the upper Tocuyo and Pozón formations.

**Cassidulina subglobosa horizontalis** Cushman and Renz

*Cassidulina subglobosa* Brady var. *horizontalis* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 26, pl. 4, fig. 8.

*Remarks*:—This subspecies has the aperture parallel to the axis of coiling. Other characters are similar to the parent species.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625995.

*Occurrence*:—Scarce and does not occur above the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

Genus **CASSIDULINOIDES** Cushman, 1927

**Cassidulinoides erecta** Cushman and Renz

*Cassidulinoides erecta* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contrib., vol. 17, p. 25, pl. 4, figs. 6-7.

*Hypotype*:—From sample, No. RM 19320, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625996.

*Occurrence*:—Scarce, only observed in a few samples from the *Globorotalia fohsi* "Zone" (*s.l.*), Pozón formation.

Genus **EHRENBURGIA** Reuss, 1850

**Ehrenbergina caribbea** Galloway and Heminway

*Ehrenbergina caribbea* Galloway and Heminway, 1941, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 426, pl. 32, figs. 4a-d.

*Ehrenbergina caribbea* Galloway and Heminway, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 131, pl. 1X, figs. 17a-b.

*Hypotype*:—From sample, No. RM 19355, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625997.

*Occurrence*:—Scarce and only observed in samples from the *Globorotalia fohsi* "Zone" (*s.l.*) and *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

Family **CHILOSTOMELLIDAE**

Genus **CHILOSTOMELLA** Reuss, 1850

**Chilostomella ovoidea** Reuss

*Chilostomella ovoidea* Reuss, 1850, K. Akad. Wiss. Wien, Math.-Nat. Cl., Denkschr., vol. 1, p. 380, pl. 48, fig. 12 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 625999.

*Occurrence*:—Scarce, only seen in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*) Tocuyo and Pozón formations. Usually badly preserved. According to Renz (1948) ranges throughout the Tocuyo formation and most of the Pozón formation.

Genus **PULLENIA** Parker and Jones, 1862**Pullenia bulloides** (d'Orbigny)

*Nonionina bulloides* d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne (Autriche), p. 107, pt. 5, figs. 9-10. (*vide* Ellis and Messina, 1940 *et seq.*).

*Pullenina bulloides* (d'Orbigny), Kleinpell, 1938, Amer. Assoc. Petr. Geol., Spec. Pub., p. 338, pl. 5, figs. 10, 13.

*Hypotype*:—From sample, No. RM 19284, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626001.

*Occurrence*:—Generally rather scarce but observed in all zones of the Tocuyo and Pozón formations below the *Sphaeroidinella seminulina* Zone.

**Pullenia salisburyi** R. E. and K. C. Stewart

*Pullenia salisburyi* R. E. and K. C. Stewart, 1930, Jour. Pal., vol. 4, p. 72, pl. 8, fig. 2 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 19283, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626003.

*Occurrence*:—Scarce and only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*), and *Globorotalia mayeri* Zone (*s.l.*), Tocuyo and Pozón formations.

Genus **SPHAEROIDINA** d'Orbigny, 1826**Sphaeroidina variabilis** Reuss

*Sphaeroidina variabilis* Reuss, 1851, Deutsch. Geol. Ges., Zeitschr., vol. 3, p. 88, pl. 7, figs. 61-64 (*vide* Ellis and Messina, 1940 *et seq.*).

*Sphaeroidina variabilis* Reuss, Cushman, 1929, Cushman Lab. Foram. Res., Contr., vol. 5, p. 101, pl. 14, figs. 15a-c.

*Remarks:*—This species shows considerable variation in size. Large specimens seem to be associated with mainly planktonic faunas. Dwarf specimens occur with *Uvigerina isidroensis-Bolivina simplex* and *Bolivina imporcata* assemblages in the lower to middle part of the *Sphaeroidinella seminulina* Zone.

*Hypotype:*—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626005.

*Occurrence:*—Occurs throughout the upper part of the Tocuyo and Pozón formations below the middle part of the *Sphaeroidinella seminulina* Zone. Most frequent in the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*) and in the *Globorotalia mayeri* Zone (*s.l.*).

#### Family HANTKENINIDAE

##### Subfamily CASSIGERINELLINAE

Genus CASSIGERINELLA Pokorný, 1955

*Cassigerinella chipolensis* (Cushman and Ponton) Pl. 7, figs. 30a-c

*Cassidulina chipolensis* Cushman and Ponton, 1932, Florida Geol. Surv., Bull., No. 9, p. 98, pl. 15, figs. 2a-c.

*Cassidulina chipolensis* Cushman and Ponton, Cushman and Stainforth, 1945, Cushman Lab. Foram. Res., Spec. Publ. 14, p. 64, pl. 12, fig. 5

*Cassigerinella chipolensis* (Cushman and Ponton), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 108, pl. 22, figs. 3a-c.

*Hypotype:*—From sample, No. RM 19304, auger line near Pozón, eastern Falcón; Plate 7, figures 30a-c, deposited in U.S.N.M. collection, No. 626007.

*Occurrence:*—Ranges from the *Catapsydrax stainforthi* Zone to the upper part of the *Globorotalia fohsi robusta* Zone, Tocuyo and Pozón formations.

##### Subfamily HASTIGERININAE

Genus HASTIGERINA Thompson, 1876

Cushman named the genus *Globigerinella* in 1927 with *Globigerina aequilateralis* Brady as the type species. Brady remarked in his type description of *Globigerina aequilateralis* that the test is "planospiral and symmetrical" but also remarked that his species approached "*Hastigerina* in general form". The apertures of Brady's species, as seen from his illustrations, are not interiomarginal, equatorial-symmetrical but asymmetric with an umbilical prolongation.

Brady also illustrated a section of his species which shows that the early stages are trochospiral, and the form is not planispiral throughout. Cushman (1927) noted in the type description of *Globigerinella* that his genus was "trochoid in the young, at least in the microspheric form", whilst Thompson (1876) defined *Hastigerina* (type species, *Hastigerina murrayi* Thompson=*Nonionina pelagica* d'Orbigny, 1839) as being trochospiral in the early stages but becoming planispiral later. As far as the writer is aware, the only difference between Cushman's and Thompson's type species are those of degree, not kind, and relate mainly to the presence or absence of coarse or fine spines. The actual nature of the spines in either form does not appear to be different. Since there does not appear to be any fundamental difference in morphology, the writer regards *Globigerinella* Cushman, 1927, as a junior synonym of *Hastigerina* Thompson, 1876.

Bolli, Loeblich, and Tappan (1957) also came to the same conclusions as the present writer concerning the validity of *Globigerinella* Cushman, 1927.

No typical specimens of *Hastigerina* (= *Globigerinella* of authors) seem to occur before the Miocene (probably not earlier than Burdigalian); species referred to *Globigerinella* from the Cretaceous by various authors (including Tappan, 1943 and Bronnemann, 1952b) seem to be more likely referable to *Biglobigerinella* Lalicker, 1948 or *Planomalina* Loeblich and Tappan, 1946.

It seems likely that *Hastigerina* has developed from a *Globorotalia* species close to *Globorotalia obesa* Bolli. In some gerontic forms of *Globorotalia obesa* from the *Globorotalia fohsi* "Zone" (*s.l.*), the last chamber shows the aperture extending over and on to the periphery, at least as far as the median line. As pointed out above, the aperture in *Hastigerina* is asymmetrical with a distinct ventral prolongation; this ventral prolongation is thought to be homologous with the interiomarginal, umbilical-extraumbilical aperture of *Globorotalia*. The stratigraphical occurrence of *Hastigerina* supports the view that it may possibly have been derived from the Miocene globorotalid stock.

**Hastigerina aequilateralis** (Brady)**Hastigerina aequilateralis aequilateralis** (Brady) Pl. 8, figs. 31a-b*Globigerina aequilateralis* Brady, 1879, Quart. Jour. Micr. Sci., London, n.s. vol. 19, p. 285, figs. 18-21 (*fide* Ellis and Messina, 1940 *et seq.*).*Globigerinella aequilateralis* (Brady), Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. 25, p. 280, pl. 21, fig. 51.*Hastigerina cf. aequilateralis* (Brady), Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 108, pl. 22, figs. 1a-2b.

*Remarks:*—Brady's figures show that there is considerable variation in the degree of involution present in this form. It seems that Recent specimens often show a greater degree of uncoiling than is present in the Miocene forms which do, however, show this tendency in the last chamber. The writer distinguishes this subspecies not entirely on the degree of involution but, more essentially, on the shape of the chambers and the nature of the aperture. This subspecies is distinguished from *Hastigerina aequilateralis involuta* (Cushman) by having subspherical, fairly well-separated chambers and by having a more distinctly asymmetric aperture which does not extend far on to the dorsal side.

*Hypotype:*—From sample, No. RM 20065, auger line near Pozón, eastern Falcón; Plate 8, figs. 31a-b, deposited in U.S.N.M. collection, No. 626009.

*Occurrence:*—Ranges from the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone to the *Globigerina bulloides* Zone, Pozón formation.

**Hastigerina aequilateralis involuta** (Cushman) Pl. 8, figs. 32a-b*Globigerina aequilateralis* Brady, var. *involuta* Cushman, 1917, U.S. Nat. Mus., Proc., vol. 51, No. 2172, p. 662. (Figures in Cushman, 1921, U.S. Nat. Mus., Bull., No. 100, vol. 4, p. 293, figs. 11a-11c.), (*fide* Ellis and Messina, 1940 *et seq.*).

*Remarks:*—This subspecies is distinguished from *Hastigerina aequilateralis aequilateralis* (Brady) in having closely appressed, ovate chambers which are distinctly pointed towards the umbilicus. This subspecies is generally more involute and has the aperture extending further over onto the dorsal side of the test (although it is still asymmetric with a distinct umbilical prolongation) than in *Hastigerina aequilateralis aequilateralis* (Brady).

*Hypotype*:—From sample, No. RM 20053, auger line near Pozón, eastern Falcón; Plate 8, figs. 32a-b, deposited in U.S.N.M. collection, No. 626011.

*Occurrence*:—Ranges from the middle part of the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone to the upper part of the *Sphaeroidinella seminulina* Zone, Pozón formation.

Family **ORBULINIDAE**

Subfamily **GLOBIGERININAE**

Genus **GLOBIGERINA** d'Orbigny, 1826

*Globigerina angustiumbilitata* (Bolli) Pl. 7, figs. 33a-c, 34

*Globigerina ciperoensis angustiumbilitata* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 109, pl. 22, figs. 12a-13c.

*Remarks*:—Bolli (1957) originally described this form as a subspecies of *Globigerina ciperoensis* Bolli, but in a recent letter to the writer he agreed that this form is now better considered as a distinct species.

*Globigerina angustiumbilitata* shows several significant differences from the two remaining subspecies of *Globigerina ciperoensis*. Firstly, as Bolli (1957, p. 109) pointed out in his original description, the rate at which the chambers increase in size is distinctly greater than in either *Globigerina ciperoensis ciperoensis* or *Globigerina ciperoensis angulisuturalis*. In this form the test is slightly more trochospiral and has a smaller and less deep umbilicus than in either of the two subspecies of *Globigerina ciperoensis*. Another important feature seen in this form is that the aperture shows a tendency towards an interiomarginal, umbilical-extraumbilical position as well as having a distinct lip. Finally, the range of this species is much more extended than that of *Globigerina ciperoensis ciperoensis* and *Globigerina ciperoensis angulisuturalis*.

*Hypotype*:—From sample, No. RM 19507, auger line near Pozón, eastern Falcón; Plate 7, figs. 33a-c, deposited in U.S.N.M. collection, No. 626013.

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the *Globigerina bulloides* Zone, Tocuyo and Pozón formations.

*Globigerina apertura* Cushman

Pl. 8, figs. 35a-b

*Globigerina apertura* Cushman, 1918, U.S. Geol. Surv., Bull., No. 676, p. 57, pl. 12, figs. 8a-c (*vide* Ellis and Messina, 1940 *et seq.*).

*Remarks:*—This species shows a large, high-arched aperture with a distinct thickened rim. The umbilicus is wide, and the chambers rather loosely coiled.

The writer's specimens compare excellently with Cushman's figured holotype, described from the Miocene of Virginia, U.S.A.

*Globigerina apertura* Cushman differs from *Globigerina ampliapertura* Bolli, 1957 by having looser coiling, a wider umbilicus, inflated and well-separated chambers. *Globigerina ampliapertura* is restricted to the uppermost Eocene and lowermost Oligocene whilst *Globigerina apertura* does not appear until the middle to upper Miocene.

*Globigerina apertura* is considered to be related to *Globigerina bulloides* d'Orbigny since *Globigerina apertura* first appears slightly later than *Globigerina bulloides*. Transitional forms between these two species are present in some samples from the upper part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone. However, *Globigerina apertura* may be distinguished from *Globigerina bulloides* by the very large and highly arched aperture, the distinctive apertural rim and the looser coiling.

*Hypotype:*—From sample, No. RM 19791, auger line near Pozón, eastern Falcón; Plate 8, figs. 35a-b, deposited in U.S.N.M. collection No. 626015.

*Occurrence:*—Ranges from the upper part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone to the *Sphaeroidinella seminulina* Zone, Pozón formation. This species may prove to be a most useful and restricted marker.

***Globigerina bradyi* Wiesner**

Pl. 7, fig. 36

*Globigerina* sp., Brady, 1884, Challenger Exped., Rept., Zool., vol. 9, p. 82, figs. 8, 9.

*Globigerina bradyi* Wiesner, 1931, Die Foraminiferen der deutschen Südpolar-Expedition 1901-1903. In: Drygalski, Deutsche Südpolar-Expedition 1901-1903, Bd. 20, (Zool. Bd. 12), p. 133 (*vide* Ellis and Messina, 1940 *et seq.*).

*Globigerina bradyi* Wiesner, Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 110, pl. 23, figs. 5a-c.

*Remarks:*—The specimens observed in the Pozón-El Mene Road section compare well with Brady's figures and those figured by Bolli (1957) from southern Trinidad. Bolli (1957) remarked

that this species may be synonymous with *Globigerinoides minuta* Natland (1938) which has sutural supplementary apertures around the base of the last chamber. However, none of the writer's specimens show secondary sutural apertures and they are, therefore, assigned to Wiesner's species.

Bolli (1957) also remarked that *Globigerina juvenilis* Bolli shows a close relationship to this species, but the present writer regards both *Globigerina juvenilis* and *Globigerina bradyi* as being distinct. The latter species is distinctly more trochospiral and the chambers less inflated than in *Globigerina juvenilis*.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 7, fig. 36, deposited in U.S.N.M. collection, No. 626017.

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the *Globigerina bulloides* Zone, and Pozón formations.

***Globigerina bulbosa* LeRoy**

Pl. 9, figs. 37a-c

*Globigerina bulbosa* LeRoy, 1944, Colorado School Mines, Quart., vol. 39, No. 3, pt. 1, p. 39, pl. 3, figs. 26, 27.

*Remarks*:—This species, which was originally described by LeRoy from the Miocene of central Sumatra, shows radially elongate and rather bulbous chambers. The chambers increase rapidly in size as added. In the eastern Falcón specimens, the aperture is seen to possess a thin lip.

This species seems to be related to *Globigerina foliata* Bolli but differs from the latter species by having radially elongate, not spherical, chambers, and in being less trochospiral with a slightly more open type of coiling.

Forms which appear to be transitional between *Globigerina foliata* and *Globigerina bulbosa* occur in the basal part of the *Globorotalia fohsi lobata* Zone. According to a letter received from H. M. Bolli, this species has now been observed in samples from the Cipero and Lengua formations of southern Trinidad.

*Hypotype*:—From sample, No. RM 19480, auger line near Pozón, eastern Falcón; Plate 9, figures 37a-c, deposited in U.S.N.M. collection, No. 625719.

*Occurrence*.—Ranges from the lower part of the *Globorotalia fohsi lobata* Zone to the upper part of the *Sphaeroidinella seminuolina* Zone, Pozón formation.

***Globigerina bulloides* d'Orbigny**

Pl. 9, figs. 38a-c

*Globigerina bulloides* d'Orbigny, 1826, Ann. Sci. Nat., Paris, sér. 1, vol. 7, p. 277. Modèles nos. 17, 76 (*vide* Ellis and Messina, 1940 *et seq.*).

*Globigerina bulloides* d'Orbigny, Cushman, 1941, (*pars*), Cushman Lab. Foram. Res., Contr., vol. 17, p. 38, pl. 10, figs. 3-7.

*Remarks*.—The writer's concept of this species is restricted to forms similar to those illustrated by Cushman (1941) as topotypes from Rimini, Italy. Cushman's illustrations agree excellently with topotype material examined by the writer and kindly supplied by the United States National Museum, Washington, D.C.

Forms referable to *Globigerina bulloides* show four chambers in the last whorl with a moderately arched interiomarginal, umbilical aperture and a fairly wide and deep umbilicus. The chambers are inflated, spherical, well separated and increase regularly in size. The test is distinctly trochospiral with usually  $2\frac{1}{2}$ -3 convolutions visible on the dorsal side. The equatorial periphery is lobate and has a subcircular profile.

The specimens from eastern Falcón compare well with the topotypes figured by Cushman and are regarded as being typical. They first appear in sediments which are considered to be not older than middle Miocene. Bolli (1950, p. 1) also pointed out that *Globigerina bulloides* probably does not appear earlier than middle Miocene.

*Globigerina diplostoma* Reuss, *Globigerina concinna* Reuss, and *Globigerina quadrilatera* Galloway and Wissler all seem to be closely related to *Globigerina bulloides*. A study of Recent *Globigerina bulloides* from the North Sea (north-east of Scotland—material kindly supplied by H. M. Bolli) and the Gulf of Paria, the Atlantic Ocean, as well as the writer's Miocene material from eastern Falcón, shows that there are transitional forms from *Globigerina bulloides*, with four chambers in the last whorl, to *Globigerina concinna* Reuss with five well-developed chambers in the last whorl. These transitional forms show the fifth chamber variable

in size, with all gradations from rudimentary to well developed. It seems likely, therefore, that *Globigerina concinna* should be regarded as a subspecies of *Globigerina bulloides*.

The study of these *Globigerina bulloides* populations has also shown that some otherwise typical but small forms often have an aberrant final chamber and appear similar to either *Globigerina diplostoma* or, more especially, to *Globigerina quadrilatera*. It is possible that these two forms should be considered synonymous with *Globigerina bulloides* or *Globigerina concinna*.

*Hypotype*:—From sample, No. RM 19791, auger line near Pozón, eastern Falcón; Plate 9, figures 38a-c, deposited in U.S.N.M. collection, No. 626019.

*Occurrence*:—Ranges from the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone to the *Globigerina bulloides* Zone, Pozón formation.

***Globigerina eamesi* Blow, sp. nov.**

Pl. 9, figs. 39a-c

*Diagnosis of species*:—Test strongly trochospiral with 11-12 chambers arranged in about three whorls and with four chambers in the last whorl; chambers subspherical, inflated but somewhat embracing, also increasing regularly and fairly slowly in size as added; equatorial periphery lobate; equatorial profile subcircular; axial periphery rounded. The sutures of the spiral side and umbilical side are depressed, radial to slightly curved. Umbilicus small, usually almost closed; aperture an elongate slit with a thin lip, interiomarginal, umbilical; wall calcareous, perforate, thin and fragile, rough to distinctly spinose, often with thick spines. Maximum diameter of holotype, 0.34 mm.

*Remarks*:—This species is characterized by the rough to spinose wall which is also thin and fragile. It differs from *Globigerina foliata* Bolli by being more trochospiral, in having a very small umbilicus, a slitlike aperture and in the chambers being less well separated.

This species is named after Dr. F. E. Eames (Chief Palaeontologist, The British Petroleum Co. Ltd., London) in recognition of his contributions to Miocene stratigraphy and also in appreciation

of the encouragement he has given the author during the preparation of this work.

*Holotype*:—From sample, No. RM 19778, auger line near Pozón, eastern Falcón; Plate 9, figures 39a-c, deposited in U.S.N.M. collection, No. 625695.

*Occurrence*:—Ranges from the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone to the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Globigerina falconensis* Blow, sp. nov.**

Pl. 9, figs. 40a-c, 41

*Diagnosis of species*:—Test low trochospiral with 10-12 chambers arranged in about  $2\frac{1}{2}$  whorls and with 4 chambers in the last whorl; chambers subspherical, slightly embracing, especially the last, increasing regularly and rather slowly in size as added; equatorial periphery lobate; axial periphery rounded; sutures of the spiral and umbilical sides radial, depressed but not much incised; umbilicus small but deep, sometimes almost closed by the strongly developed lip of the last chamber; aperture an elongate low arch or sometimes rather slitlike with a well-developed lip, interiomarginal, umbilical; wall calcareous, rather coarsely perforate. Maximum diameter or holotype, 0.34 mm.

*Remarks*:—This species is distinguished from *Globigerina foliata* Bolli in having slightly embracing chambers and an elongate aperture with a well-developed apertural lip.

*Holotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 9, figures 40a-c, deposited in U.S.N.M. collection, No. 625697. Plate 9, figure 41, paratype, also deposited in U.S.N.M. collection, No. 625698.

*Occurrence*:—Ranges from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone to the *Globigerina bulloides* Zone, Tocuyo and Pozón formations.

***Globigerina foliata* Bolli**

Pl. 10, figs. 42a-c

*Globigerina foliata* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 111, pl. 24, figs 1a-c.

*Remarks*:—This species is distinguished by having almost spherical and well-separated chambers which increase rapidly as

size is added. The last chamber, however, is often smaller than the penultimate chamber.

*Hypotype*:—From sample, No. RM 19697, auger line near Pozón, eastern Falcón; Plate 10, figures 42a-c, deposited in U.S.N.M. collection, No. 626021.

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the upper part of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

***Globigerina juvenilis* Bolli**

Pl. 10, figs. 43a-b

*Globigerina juvenilis* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 110, pl. 24, figs. 5a-6.

*Remarks*:—This small species has inflated chambers, a small umbilicus and thin, finely perforate walls. The aperture is a narrow elongate slit usually with a thin but distinctive lip.

In some forms, which are still probably referable to this species, the lip abuts closely onto the ventral surface of the opposing chamber appearing much like a narrow bulla. These forms appear transitional to *Globigerinita*.

Bolli (1957) considered that this species may possibly represent the juvenile state of *Globigerinita naparimaensis* Bronnimann, but the present writer is inclined to view that this form is a distinct species from which *Globigerinita* developed heterochronously at various levels throughout the Miocene.

*Hypotype*:—From sample, No. RM 19507, auger line near Pozón, eastern Falcón; Plate 10, figures 43a b, deposited in U.S.N.M. collection, No. 626023.

*Occurrence*:—Ranges throughout all zones of the Tocuyo and Pozón formations as seen in the Pozón-El Mene Road Section.

***Globigerina nepenthes* Todd**

Pl. 8, figs. 44, 45

*Globigerina nepenthes* Todd, 1956, U.S. Geol. Surv., Prof. Paper 280-H, p. 301, pl. 78, fig. 7.

*Globigerina nepenthes* Todd, Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 111, pl. 24, figs. 2a-c.

*Remarks*:—This distinctive species shows trends towards becoming more tightly coiled and the chambers more strongly embracing. Concomitant with these trends, there is also a further

trend wherein the wall becomes thicker and the aperture less strongly arched so that later forms of the species appear rather *Sphaeroidinella*-like (Pl. 8, fig. 45).

*Hypotype*:—From sample, No. RM 20026, auger line near Pozón, eastern Falcón; Plate 8, figure 44, deposited in U.S.N.M. collection No. 626025. Figure 45, from sample, No. RM 20065, also deposited in U.S.N.M., collection, No. 626027.

*Occurrence*:—Ranges from the base of the *Globorotalia mayeri*/*Globigerina nepenthes* Subzone to the top of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Globigerina parabulloides*** Blow, sp. nov.

Pl. 10, figs. 46a-c

*Diagnosis of species*:—Test trochospiral with 9-10 chambers arranged in about three whorls and with four chambers in the last whorl; chambers ovate to subspherical, inflated and rather embracing, sometimes slightly appressed, increasing moderately rapidly in size as added so that the equatorial profile of the test appears distinctly elongate in the direction of the last chamber; equatorial periphery strongly lobate; axial periphery rounded; sutures of the spiral side depressed, radial to slightly curved; sutures of the umbilical side depressed but not deeply incised, radial; umbilicus small, rather shallow; aperture a low arch restricted in lateral extent to the umbilical depression, interiomarginal, umbilical, and with a distinct lip or thickened rim; wall calcareous, perforate, rather thick; maximum diameter of holotype, 0.34 mm.

*Remarks*:—This species differs from *Globigerina praebulloides* Blow, sp. nov. in having a laterally restricted aperture with a distinctive lip or thickened rim, a small and shallow umbilicus, a distinctly more trochospiral test which is more precisely coiled and inflated chambers.

This species differs from *Globigerina bulloides* d'Orbigny in having a much smaller and restricted aperture, a smaller umbilicus, less deeply incised sutures and an elongate equatorial profile. *Globigerina parabulloides* is considered to be descended from *Globigerina praebulloides* but appears earlier than *Globigerina bulloides*.

Transitional forms from *Globigerina praebulloides* to *Globi-*

*gerina parabulloides* occur in the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone.

*Holotype*:—From sample, No. RM 19791, auger line near Pozón, eastern Falcón; Plate 10, figures 46a-c, deposited in U.S.N.M. collection, No. 625699.

*Occurrence*:—Ranges from the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone to the *Globigerina bulloides* Zone, Pozón formation.

***Globigerina praebulloides*** Blow, sp. nov. Pl. 8, figs. 47a-c; Pl. 9, 48

*Globigerina* aff. *bulloides* d'Orbigny, Stainforth, 1948, (*pars*), Jour. Pal., vol. 22, No. 2, p. 118, pl. 25, figs. 14, 15 (*non* figs. 16-18).

*Diagnosis of species*:—Test weakly trochospiral with 8-9 chambers arranged in about  $2\frac{1}{2}$  whorls, with usually 4, occasionally 5, chambers in the last whorl. The fifth chamber, when present, only rudimentary or small; chambers ovate, not much inflated but appressed and often slightly embracing, increasing rapidly in size as added so that the equatorial profile of the test appears distinctly elongate in the direction of the last chamber; equatorial periphery lobate; axial periphery rounded; sutures of the spiral and umbilical sides depressed but rather shallow, radial to slightly curved; umbilicus small and not deep; aperture a low to moderate arch, interiomarginal, umbilical; wall calcareous, perforate; maximum diameter of holotype, 0.30 mm.

*Remarks*:—This species differs from *Globigerina bulloides* d'Orbigny in having an elongate, not subcircular, equatorial profile, and chambers which are normally ovate, appressed and often slightly embracing. The chambers increase more rapidly in size in this species and the coiling is less trochospiral and not so precise as in *Globigerina bulloides*. This species also differs from *Globigerina bulloides* in having a comparatively smaller, less strongly arched aperture and the test is consistently smaller in size.

Stainforth (1948b, p. 118) noted the same characters as recorded above for forms he referred to as *Globigerina* aff. *bulloides* "form A", from the Oligocene of Ecuador; however, Stainforth described two different forms as *Globigerina* aff. *bulloides*, and his "form B" (Stainforth, 1948b, p. 121—explanation of plate 25, figs.

16-18) seems referable to the genus *Globorotalia*.

*Globigerina praebulloides* is considered as being ancestral to both *Globigerina bulloides* and *Globigerina parabulloides*.

*Holotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 8, figures 47a-c, deposited in U.S.N.M. collection, No. 625701. Figured paratype (Pl. 9, fig. 48) also deposited in U.S.N.M. collection, No. 625702.

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Tocuyo and Pozón formations.

#### Genus **GLOBOQUADRINA** Finlay, 1947

The species referred to this genus have several features in common. One of the most important biocharacters is the peculiar toothlike flap (or projection) which restricts and modifies the aperture and projects into the umbilical depression. This toothlike flap is regarded as being distinctly different from a normal lip seen in some species of *Globigerina*. In *Globoquadrina* the umbilical teeth (Bolli, Loeblich, and Tappan, 1957) lie within the umbilical depression, are usually pointed and often elongate, with an asymmetric outline as viewed from above.

Normally the aperture, in the various adult species of *Globoquadrina* discussed here, is interiomarginal, umbilical, but shows a tendency towards an interiomarginal, umbilical-extraumbilical position in some species, especially in juvenile forms or in the earlier chambers as seen in broken specimens.

Members of this genus typically show lateral compression of the later chambers.

#### ***Globoquadrina dehiscens dehiscens*** (Chapman, Parr, and Collins)

Two groups of forms, which are regarded as subspecies, have been observed in the Pozón-El Mene Road section. The form described as *Globoquadrina quadraria* (Cushman and Ellisor) 1939, is regarded as being close to *Globoquadrina dehiscens*, and it is not possible to separate these two forms when dealing with a population. However, the type described as *Globoquadrina quadraria* var. *advena* Bermudez is distinctive and appears to have a different

stratigraphical range. Bermudez's variety is, however, regarded as being closely related to *Globoquadrina dehiscens*, and since the name given by Chapman, Parr, and Collins in 1934 has priority, the variety "*advena*" is considered as a subspecies of *Globoquadrina dehiscens* (Chapman, Parr, and Collins).

***Globoquadrina dehiscens dehiscens*** (Chapman, Parr, and Collins)

Pl. 8, figs. 49a-c

*Globoquadrina dehiscens* Chapman, Parr, and Collins, 1934, Linn. Soc. London, Jour. Zool., vol. 38, No. 262, p. 569, pl. 11, figs. 36a-c (*vide* Ellis and Messina, 1940 *et seq.*).

*Remarks*:—This subspecies possesses a fairly wide umbilicus, also distinctive asymmetrical umbilical teeth. The chambers are generally not much embracing, and the sutures are distinct. It often shows much lateral compression of the later chambers, with a resultant quadrate outline.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 8, figures 49a-c, deposited in U.S.N.M. collection, No. 626028.

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the lower part of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

***Globoquadrina dehiscens advena*** Bermudez

Pl. 8, figs. 50a-b

*Globoquadrina quadraria* (Cushman and Ellisor) var. *advena* Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. 25, p. 287, pl. 22, figs. 36-38.

*Remarks*:—This subspecies possesses a comparatively small, sometimes almost closed, umbilicus. The chambers are closely coiled and embracing, with the sutures indistinct.

In general, the test appears rather quadrate, but it may appear almost subspherical owing to the tight coil, embracing chambers, and the lateral compression of the later chambers.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 8, figs. 50a-b, deposited in U.S.N.M. collection, No. 626030.

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the *Globoquadrina mayeri*/*Globoquadrina linguaensis* Subzone, Tocuyo and Pozón formations.

**Globoquadrina altispira** (Cushman and Jarvis)**Globoquadrina altispira altispira** (Cushman and Jarvis) Pl. 8, figs. 51a-c*Globigerina altispira* Cushman and Jarvis, 1936, Cushman Lab. Foram. Res., Contr., vol. 12, pt. 1, p. 5, pl. 1, figs. 13a-c. 14 (*vide* Ellis and Messina, 1940 *et seq.*).*Globoquadrina altispira altispira* (Cushman and Jarvis), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 111, pl. 24, figs. 7a-8b.

*Remarks:*—This subspecies possesses axially elongate and often fairly strongly laterally compressed chambers. Distinct asymmetrical umbilical teeth occur.

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 8, figures 51a-c, deposited in U.S.N.M. collection, No. 626032.

*Occurrence:*—Ranges from the *Catapsydrax stainforthi* Zone to the basal part of the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone, Tocuyo and Pozón formations.

**Globoquadrina altispira globosa** Bolli

Pl. 11, figs. 52a-c

*Globoquadrina altispira globosa* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 111, pl. 24, figs. 9a-10c.

*Remarks:*—This subspecies is distinguished from *Globoquadrina altispira altispira* (Cushman and Jarvis) by having more globular and less axially elongate chambers. Well-marked, slightly asymmetrical umbilical teeth are present.

*Hypotype:*—From sample, No. RM 19542, auger line near Pozón, eastern Falcón; Plate 11, figures 52a-c, deposited in U.S.N.M. collection, No. 626034.

*Occurrence:*—Ranges from the *Catapsydrax stainforthi* Zone to the top of the *Globigerinatella insueta*/*Globigerinoides bisphERICA* Subzone and then reappears at the base of the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone ranging up to the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Tocuyo and Pozón formations. The subspecies does not seem to occur in the intervening *Globorotalia fohsi* "Zone" (*s.l.*) either in southern Trinidad or in eastern Falcón.

**Globoquadrina larmei** Akers

Pl. 11, figs. 53a-c

*Globoquadrina larmei* Akers, 1955, Jour. Pal., vol. 29, No. 4, p. 661, pl. 65, figs. 4a-4c.

*Remarks:*—The specimens from eastern Falcón compare well with the figures given by Akers. As Akers (1955) remarked this species is closer to the genus *Globigerina* than other recorded species of the genus *Globoquadrina*. However, the umbilical teeth are distinctive and the aperture shows a slight tendency towards an interiomarginal, umbilical-extraumbilical position.

The umbilicus of this species is shallow especially when compared to other species of *Globoquadrina*.

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 11, figures 53a-c, deposited in U.S.N.M. collection, No. 625721.

*Occurrence:*—Occurs from the top of the *Catapsydrax stainforthi* Zone to the *Globorotalia mayeri*/*Globigerina nepenthes* Subzone. Tocuyo and Pozón formations.

*Globoquadrina pozonensis* Blow, sp. nov.

Pl. 10, figs. 54a-c, 55, 56

*Diagnosis of species:*—Test distinctly trochospiral with 11-12 chambers arranged in about  $2\frac{1}{2}$  whorls and with 4-5 chambers in the last whorl; chambers subspherical to ovate but sometimes rather appressed and also slightly compressed laterally; equatorial periphery lobate; equatorial profile subcircular; axial periphery rounded; sutures of the spiral and umbilical sides radial and depressed; umbilicus rather small but deep; aperture a rather small arched opening with a distinct umbilical tooth; in the adult generally interiomarginal, umbilical, but in some specimens (Pl. 10, fig. 55) interiomarginal, umbilical-slightly extraumbilical; apertures of the early chambers and in juvenile specimens distinctly interiomarginal, umbilical-extraumbilical; wall calcareous, coarsely perforate and often rather rough to slightly spinose; maximum diameter of holotype, 0.28 mm.

*Remarks:*—This species shows a distinctly interiomarginal, umbilical-extraumbilical aperture in the early chambers which becomes generally interiomarginal, umbilical in the adult. The umbilical teeth, although small, are distinct. The sutures are usually distinct, notwithstanding the rather appressed and laterally compressed chambers seen in some specimens.

*Globoquadrina pozonensis* distinguished from *Globoquadrina altispira globosa* Bolli by the rather more appressed chambers, relatively smaller umbilicus, relatively smaller aperture and consistently smaller test and by the coarsely perforate and rather rough wall.

*Holotype*:—From sample, No. RM 20065, auger line near Pozón, eastern Falcón; Pl. 10, figures 54a-c, deposited in U.S.N.M. collection, No. 625703. (Figured paratypes from same sample also deposited in U.S.N.M.)

*Occurrence*:—Ranges from the *Globorotalia mayeri*/*Globigerina nepenthes* Subzone to the *Globigerina bulloides* Zone, Pozón formation.

***Globoquadrina rohri* (Bolli)**

Pl. 11, figs. 57a-c

*Globigerina rohri* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 109, pl. 23, figs. 1a-4b.

*Remarks*:—Bolli (1957) placed his species in the genus *Globigerina* and did not mention the occurrence of umbilical teeth. Bolli also pointed out that in his specimens the umbilicus is small and almost closed. Most of the writer's specimens also show the nearly closed umbilicus, but some specimens show a rather wider umbilicus and a well-marked asymmetrical umbilical tooth; in other respects these specimens show no further differences in morphology.

Bolli (1957) recorded this species as occurring not higher than the *Catapsydrax dissimilis* Zone but the writer's specimens come from the lower part of the overlying *Catapsydrax stainforthi* Zone, and the more open umbilicus may be a more advanced feature of some phylogenetic significance. These forms with the wider umbilicus and distinctive umbilical teeth show some features in common with the *Globoquadrina dehiscens* group and it seems likely that *Globoquadrina rohri* may be the ancestor of *Globoquadrina dehiscens*.

*Holotype*:—From sample, No. RM 19117, auger line near Pozón, eastern Falcon; Plate 11, figures 57a-c, deposited in U.S.N.M. collection, No. 626036.

*Occurrence*:—Occurs only in the lower part of the *Catapsydrax stainforthi* Zone, Tocuyo formation.

**Globoquadrina venezuelana** (Hedberg)

Pl. 11, figs. 58a-c, 59

*Globigerina venezuelana* Hedberg, 1937, Jour. Pal., vol. 11, No. 8, p. 681, pl. 92, figs. 7a-b.

*Remarks:*—This species is referred to the genus *Globoquadrina* Finlay, as Finlay (1947) suggested. Inspection of Hedberg's (1937) type figure 7a shows a pointed umbilical tooth projecting into the umbilicus; this feature has been seen in all the writer's specimens, although the umbilical teeth may be small and in some cases rudimentary.

Bolli (1957) discussed the variation in size and shape of the chambers of this species as seen in the Cipero and Lengua formations of southern Trinidad, and a similar variation is seen in eastern Falcón. However, the differences in morphology seem to be variable and not sufficiently constant for taxonomic subdivision of the species. Besides the variation in lateral compression of the chambers as noted by Bolli (1957), the writer has noted that forms with a closed or nearly closed umbilicus and with small umbilical teeth are most frequent from the *Catapsydrax stainforthi* Zone to *Globorotalia fohsi fohsi* Zone, whilst forms with comparatively more open umbilici and more distinct umbilical teeth occur most frequently from the *Globorotalia fohsi lobata* Zone to the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone. In the *Sphaeroidinella seminulina* Zone and in the *Globigerina bulloides* Zone only the forms with the larger umbilici and more distinctive umbilical teeth have been observed. (See fig. 59.)

*Hypotype:*—From sample, No. RM 19188, auger line near Pozón, eastern Falcón; Plate 11, figures 58a-c, deposited in U.S.N.M. collection No. 626038. Plate 11, figure 59, from sample, No. RM 19542, deposited in U.S.N.M. collection, No. 626040.

*Occurrence:*—Ranges throughout the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone to *Globigerina bulloides* Zone), Tocuyo and Pozón formations.

Genus **GLOBIGERINOIDES** Cushman, 1927

**Globigerinoides triloba** (Reuss)

The writer agrees with the views of Bolli (1957, p. 112) regarding the relationship of both *Globigerinoides sacculifera* (Brady)

and a form recorded by LeRoy (1939) as *Globigerinoides sacculifera immatura* to *Globigerinoides triloba* (Reuss). Forms transitional between these species are often difficult to place with certainty. This is especially so for *Globigerinoides triloba* (Reuss) and *Globigerinoides sacculifera immatura* LeRoy, whilst a study of the ontogeny of *Globigerinoides sacculifera* (Brady) shows that it is only the possession of a saclike, elongate final chamber which distinguishes this form from *Globigerinoides sacculifera immatura* LeRoy. These closely related forms, which appear practically at the same time in the *Globorotalia kugleri* Zone (Bolli, 1957), are treated here as subspecies of *Globigerinoides triloba* (Reuss), since Reuss's name has priority. Bolli (1957) described another form, which is closely related to this group, as *Globigerinoides triloba altiapertura*.

***Globigerinoides triloba triloba* (Reuss)**

Pl. 11, figs. 60a-b

*Globigerina triloba* Reuss, 1850, K. Akad. Wiss, Wien, Math.-Nat. Cl., Denkschr., vol. 1, p. 374, pl. 47, figs. 11a-d (*vide* Ellis and Messina, 1940 *et seq.*).

*Globigerinoides triloba* (Reuss), Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 62, text-fig. 1, Nos. 1-3.

*Globigerinoides triloba triloba* (Reuss), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 112, pl. 25, figs. 2a-c.

*Remarks:*—This is distinguished from *Globigerinoides triloba immatura* LeRoy in having a more inflated final chamber which embraces more of the earlier test. It has, in general, a more elongate and narrower primary aperture than *Globigerinoides triloba immatura* LeRoy.

*Holotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 11, figures 60a-b, deposited in U.S.N.M. collection, No. 626125.

*Occurrence:*—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the *Globigerina bulloides* Zone, Tocuyo and Pozón formations.

***Globigerinoides triloba altiapertura* Bolli**

Pl. 10, figs. 61a-b

*Globigerinoides triloba altiapertura* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 113, pl. 25, figs. 7a-8.

*Remarks:*—This subspecies is distinguished from other sub-

species of the *triloba* group by having a large and highly arched primary aperture. It is distinguished from *Globigerinoides bollii* Blow, sp. nov. by having inflated, spherical chambers, and larger supplementary apertures; the chambers are, moreover, not embracing.

*Hypotype*:—From sample, No. RM 19152, auger line near Pozón, eastern Falcón; Plate 10, figures 61a-b, deposited in U.S.N.M. collection, No. 626127.

*Occurrence*:—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the lower part of the *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation.

***Globigerinoides triloba immatura* LeRoy**

Pl. 11, figs. 62a-b

*Globigerinoides sacculiferus* (Brady) var. *immatura* Leroy, 1939, *Natuurk. Tijdschr. Nederl.-Indië*, deel 99, afl. 6, p. 263, pl. 3, figs. 19-21 (*vide* Ellis and Messina, 1940, *et seq.*).

*Globigerinoides triloba immatura* LeRoy, Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 113, pl. 25, figs. 3a-4c.

*Remarks*:—This subspecies differs from *Globigerinoides triloba sacculifera* (Brady) by not having a saclike elongate final chamber.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 11, figures 62a-b, deposited in U.S.N.M. collection, No. 626129.

*Occurrence*:—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the *Globigerina bulloides* Zone, Tocuyo and Pozón formations.

***Globigerinoides triloba sacculifera* (Brady)**

Pl. 11, figs. 63a-b

*Globigerina sacculifera* Brady, 1877, *Geol. Mag.*, n.s. decade 2, vol. 4, No. 12, p. 535, figures in Brady, 1884, *Challenger Exped. Rept., Zool.*, vol. 9, pl. 90, figs. 15 and 16 (*vide* Ellis and Messina, 1940 *et seq.*).

*Globigerinoides triloba sacculifera* (Brady), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 113, pl. 25, figs. 5a-6.

*Remarks*:—This subspecies is distinguished by the characteristic saclike, final chamber. Both the primary and the dorsal supplementary apertures of the last chambers seem to be rather more strongly arched than the apertures of the last chamber of *Globigerinoides triloba immatura* LeRoy.

*Hypotype*:—From sample, No. RM 19697, auger line near Pozón, eastern Falcón; Plate 11, figures 63a-b, deposited in U.S.N.M. collection, No. 626131.

*Occurrence*:—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the *Globigerina bulloides* Zone, Tocuyo and Pozón formations.

***Globigerinoides bispherica* Todd**

Pl. 11, fig. 64

*Globigerinoides bispherica* Todd, 1954, Amer. Jour. Sci., vol. 252, No. 11, p. 681, pl. 1, figs. 1a-c.

*Globigerinoides bispherica* Todd, Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 62, text-fig. 1, Nos. 4-8; text-fig. 2, Nos. 10-11.

*Globigerinoides bispherica* Todd, Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 114, pl. 27, figs. 1a-b.

*Remarks*:—Blow (1956) emended the original description of Todd (1954) in order to recognize *Porticulasphaera glomerosa* (Blow). As emended, *Globigerinoides bispherica* shows two to four apertures along the suture between the last and earlier chambers. The last chamber embraces about 15 to 35 percent of the penultimate and earlier chambers. The primary aperture is still distinct, although it is elongate and often partially constricted by ingrowths of clear shell material which tend to subdivide it.

This species is regarded as the ancestor of *Porticulasphaera glomerosa* (Blow) and *Porticulasphaera transitoria* (Blow).

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 11, figure 64, deposited in U.S.N.M. collection, No. 626133.

*Occurrence*:—Ranges from the base of the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone to the lower part of the *Globorotalia fohsi barisanensis* Zone, Tocuyo, and Pozón formations.

***Globigerinoides bollii* Blow, sp. nov.**

Pl. 10, figs. 65a-c

*Diagnosis of species*:—Test trochospiral with four chambers in the last whorl; equatorial periphery lobate; axial periphery rounded; chambers subspherical or ovate, much embracing; sutures of the spiral and umbilical sides depressed but often indistinct, radial to slightly curved; umbilicus small, often almost completely closed; primary aperture interiomarginal, umbilical, the opening

almost completely circular but generally rather small; supplementary apertures on the spiral side, sutural, small; usually only one present, situated in the suture between the last chamber and its predecessor, although an additional supplementary aperture may be present in the suture between the penultimate and antepenultimate chambers; wall calcareous, perforate, often rather thick; maximum diameter of holotype, 0.34 mm.

*Remarks:*—This species differs from *Globigerinoides obliqua* Bolli in having much more embracing chambers, a small, almost circular, primary aperture, and in the last few chambers not showing any lateral and oblique compression. A characteristic of this species is the “cut-in” nature of the umbilical margin of the primary aperture. Early forms of this species only show one supplementary aperture on the spiral side which is situated in the suture between the last and penultimate chambers. However, in later forms from the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, an additional supplementary aperture appears in the suture between the penultimate and antepenultimate chambers.

This species seems to have a different origin from that of the *Globigerinoides triloba* group. According to Bolli (1957), *Globigerinoides triloba* (Reuss) appears to originate in the *Globorotalia kugleri* Zone and to develop from a form recorded by him as *Globigerina* cf. *trilocularis* d'Orbigny. However, *Globigerinoides bollii* does not appear until the basal part of the *Globorotalia mayeri*/*Globigerina nepenthes* Subzone and seems to have originated from a *Globigerina* sp., which has an otherwise similar morphology to this species but does not have supplementary apertures. This *Globigerina* sp. is scarce and appears to be limited to the upper part of the *Globorotalia fohsi robusta* Zone.

This species is named after Dr. H. M. Bolli in recognition of the valuable training the writer received from him whilst in Trinidad.

*Holotype:*—From sample, No. RM 19697, auger line near Pozón, eastern Falcón; Plate 10, figures 65a-c, deposited in U.S.N.M. collection, No. 625717.

*Occurrence:*—Ranges from the base of the *Globorotalia may-*

*eri/Globorotalia linguaensis* Subzone to the *Globigerina bulloides* Zone, Pozón formation.

***Globigerinoides diminuta* Bolli**

Pl. 13, figs. 66a-b

*Globigerinoides diminuta* Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 114, pl. 25, figs. 11a-c.

*Remarks:*—This species is distinguished from *Globigerinoides rubra* (d'Orbigny) by its more embracing chambers, its distinctly quadrate outline, and its consistently smaller size.

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 13, figures 66a-b deposited in U.S.N.M. collection, No. 626135.

*Occurrence:*—Ranges from the upper part of the *Globigerinatella insueta/Globigerinoides triloba* Subzone to the top of the *Globigerinatella insueta/Globigerinoides bisphérica* Subzone, Tocuyo and Pozón formations. It is a useful marker for this interval.

***Globigerinoides mitra* Todd**

Pl. 13, fig. 67

*Globigerinoides mitra* Todd, 1956, U.S. Geol. Surv., Prof. Paper 280-H, p. 302, pl. 78, figs. 3,6.

*Globigerinoides mitra* Todd, Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 114, pl. 26, figs. 1a-4.

*Remarks:*—Only a few specimens of this particularly high-spired and large species of *Globigerinoides* have been observed in the Pozón formation.

The occurrence of this species seems to be strongly influenced by ecological conditions and to occur in faunas which are suggestive of a deepwater environment.

The observed specimens appear to be typical and compare well with those figured by both Todd and Bolli in spite of the comparatively poor preservation and adherent matrix.

*Hypotype:*—From sample, No. RM 19507, auger line near Pozón, eastern Falcón; Plate 13, figure 67, deposited in U.S.N.M. collection, No. 626137

*Occurrence:*—Only observed in isolated samples from the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

***Globigerinoides obliqua* Bolli**

Pl. 11, figs. 68a-b

*Globigerinoides obliqua* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 113, pl. 25, figs. 9a-10c

*Remarks*:—This species is distinguished from the *Globigerinoides triloba* group by having the last, or last few, chambers compressed in a lateral and oblique manner. Although Bolli (1957) referred to his species as having a small umbilicus, there is a general trend, in sediments above the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone, towards the coiling becoming more lax and the umbilicus becoming larger. Also, concomitant with this trend towards laxity of coiling, the chambers become increasingly more separated.

A typical feature of this species is the elongate, although arched, primary aperture.

*Holotype*:—From sample No. RM 19444, auger line near Pozón, eastern Falcón; Plate 11, figures 68a-b, deposited in U.S.N.M. collection, No. 626041.

*Occurrence*:—Ranges throughout the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone to *Globigerina bulloides* Zone), Tocuyo and Pozón formations.

***Globigerinioides rubra*** (d'Orbigny)      Pl. 11, fig. 70; Pl. 13, figs. 69a-b

*Globigerinoides subquadrata* Bronnimann, in Todd, Cloud, Low, and Schmidt, 1954, Amer. Jour. Sci., vol. 252, p. 680, pl. 1, fig. 5.

*Globigerinoides rubra* (d'Orbigny), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 113, pl. 25, figs. 12a-13b.

*Remarks*:—This species is distinguished by the position of the primary and supplementary sutural apertures which are always symmetrically placed above the suture between two earlier chambers.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcon; Plate 13, figures 69a-b, deposited in U.S.N.M. collection, No. 626043. Plate 11, figure 70, from sample, No. RM 20131, deposited in U.S.N.M. collection, No. 626045.

*Occurrence*:—Ranges throughout all zones of the upper Tocuyo and Pozón formations and is common to abundant below the lower part of the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone. The species becomes scarce and has only been observed infrequently in the upper part of the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone and the *Globorotalia mayeri*/*Globigerina nepenthes*

Zone, but it becomes fairly frequent again in the *Sphaeroidinella seminulina* and the *Globigerina bulloides* Zones, Pozón formation.

Genus **SPHAEROIDINELLA** Cushman, 1927

Cushman erected this genus in 1927 with *Sphaeroidina dehiscens* Parker and Jones as the type species. However, the generic description of Cushman is somewhat misleading since he states "Test in early stages like *Globigerina* with coarsely cancellate surface". Cushman did not mention the characteristic thick and "polished" wall of the adult. *Sphaeroidinella dehiscens* (Parker and Jones) possesses a thick wall with a smooth outer surface which appears rather glassy and "polished" in reflected light. The writer made sections of *Sphaeroidinella dehiscens dehiscens* (Parker and Jones), *Sphaeroidinella dehiscens subdehiscens* Blow, subsp. nov. and *Sphaeroidinella seminulina seminulina* (Schwager) and found the wall structure similar in each of these forms. The typical wall structure is shown in the camera lucida drawing (Pl. 12, fig. 72) of a section of *Sphaeroidinella dehiscens subdehiscens*.

In thin section, the wall of *Sphaeroidinella* appears to be composed of three layers:

(a) a thin external "cortex", (b) a thick middle layer, (c) a thin inner layer (see fig. 72, Pl. 12)

(a) *External Cortex*.

The actual structure of the outer cortex is difficult to determine but, between crossed nicols, shows interference colours of a lower order than either the middle or innermost layer. It is thought that this outer cortex may be lamellar in structure but it cannot be considered as "imperforate" since pores are present but are much reduced in size as compared with the pores present in the middle and innermost layers. In reflected light this cortex appears hyaline and smooth with a polished appearance.

The outer cortex also appears more liable to alteration and solution than the other layers since it has been noticed that pyritization and limonitization often affect the cortex but not the inner layers. Further, the writer has noticed specimens in which the cortex has been removed from a part of the test, so exposing the middle layer which then appears very coarsely perforate. In *Sphaeroidinella dehiscens subdehiscens* Blow, subsp. nov., for a specimen

0.35 mm. maximum dimension, this outer cortex (over the chambers) is in the order of 0.005 mm. to 0.006 mm. thick as compared with a total wall thickness of between 0.05 mm. and 0.06 mm. In the apertural and sutural regions of the test the cortex becomes much thicker (see fig. 72, Pl. 12).

(b) *Thick Middle Layer.*

This thick middle layer comprises most of the test wall and is in the order of between 0.045 mm. and 0.055 mm. thick. The structure of this layer appears to be coarsely radial with large "bundles of fibres" arranged approximately at right-angles to the test surfaces. The pores are large in this layer, being about 0.008 to 0.01 mm. in diameter but becoming, abruptly, much narrower at the junction of the outer cortex and this layer. It also seems likely that not all the pores present in this layer continue to the exterior via the cortex. The large pores of this layer can be seen through the glassy outer cortex in reflected light.

(c) *Innermost Layer.*

This layer also appears to be radial in structure but rather finely so. The writer has not observed any significant difference in the diameter of the pores within this layer and as seen in the middle layer.

***Sphaeroidinella dehiscens* (Parker and Jones)**

The writer now considers that certain Miocene forms previously referred to this species (Stainforth, 1948b; Weiss, 1955) should be separated at subspecific-level from the Pliocene to Recent, typical *Sphaeroidinella dehiscens* such as those figured by Wiseman and Ovey (1950, pl. 3 fig. 4), Phleger, Parker, and Pierson (1953, pl. 2, fig. 19), and also Kane (1953, pl. 2, fig. 23). The writer is indebted to Miss R. Todd (U. S. Geological Survey, Washington, D.C.) who sent specimens of Recent *Sphaeroidinella dehiscens* from near Bikini Atoll, Marshall Islands. Following the examination of this Recent material, as well as specimens from the Pliocene and Pleistocene of Sicily, two subspecies of this form should be distinguished as *Sphaeroidinella dehiscens dehiscens* (Parker and Jones) and *Sphaeroidinella dehiscens subdehiscens* Blow, subsp. nov.

**Sphaeroidinella dehiscens dehiscens** (Parker and Jones)

*Sphaeroidina bulloides* d'Orbigny var. *dehiscens* Parker and Jones, 1865, Roy. Soc. London, Phil. Trans., vol. 155, p. 369, pl. 19, figs. 5a-c (*vide* Ellis and Messina 1940 *et seq.*).

*Remarks*:—In *Sphaeroidinella dehiscens dehiscens* the test is large with the chambers much embracing and with little external trace of the sutures between the penultimate and earlier chambers. The apertures are deep-set, elongate, with very strongly crenulate margins. Furthermore, in typical specimens of this form a distinct and well-marked supplementary aperture occurs in addition to the primary umbilical aperture.

**Sphaeroidinella dehiscens subdehiscens** Blow, subsp. nov.

Pl. 12, figs. 71a-c, 72

*Sphaeroidinella rutschi* Cushman and Renz, Renz, 1948. (*pars*), Geol. Soc. Amer., Mem. 32, p. 167, pl. X, fig. 1c (refigured paratype), *non* figs. 1a-1b (refigured holotype).

*Sphaeroidinella dehiscens* Stainforth (*non* Parker and Jones), 1948, Jour. Pal., vol. 22, No. 2, p. 124, pl. 26, fig. 20.

*Sphaeroidinella dehiscens* Weiss, (*non* Parker and Jones), 1955, Micropalaeontology, vol. 1, p. 313, pl. 3, figs. 28-29.

*Sphaeroidinella rutschi* Cushman and Renz, Bolli, 1957, U. S. Nat. Mus., Bull., No. 215, p. 115, pl. 26, figs. 6a-7b.

*Diagnosis of subspecies*:—Test low trochospiral with three, seldom with three and one half, chambers in the last whorl; chambers, in general, rather embracing, sutures not depressed but usually fairly distinct, especially the suture between the last and earlier chambers; equatorial periphery slightly lobate with the test appearing ovate in equatorial profile; axial periphery rounded; umbilicus small or closed; aperture interiomarginal, umbilical, an elongate slit or low arch, often with thickened and crenulate margins composed essentially of a thickening of the outer cortex; wall calcareous, thick, composed of an outer cortex and a thick inner part which is radial in structure; inner part coarsely perforate, outer part smooth and glassy in reflected light; maximum diameter of holotype, 0.50 mm.

*Remarks*:—This subspecies is distinguished from *Sphaeroidinella dehiscens dehiscens* (Parker and Jones) by its less embracing chambers, more distinctive sutures, less deeply set aperture, absence of supplementary apertures, a slightly more lobate equa-

torial periphery and a generally smaller overall test size. It is interesting to observe that C. D. Redmond (in Stainforth, 1948b, p. 124) recorded this form from the Miocene of Colombia, but did not regard it as typical *Sphaeroidinella dehiscens dehiscens*.

Recently, the writer observed this subspecies in Sicily where, in the uppermost Miocene/basal Pliocene, transitional forms to *Sphaeroidinella dehiscens dehiscens* occur. Transitional forms from *Sphaeroidinella seminulina seminulina* (Schwager) (Pl. 12, fig. 73) occur in the uppermost part of the *Globorotalia fohsi robusta* Zone both in Trinidad and eastern Falcón.

*Holotype*:—From sample, No. RM 19514, auger line near Pozón, eastern Falcon; Plate 12, figures 71a-c, deposited in U.S.N.M. collection No. 625705.

*Occurrence*:—Ranges from the uppermost part of the *Globorotalia fohsi robusta* Zone to the *Globigerina bulloides* Zone, Pozón formation.

#### ***Sphaeroidinella seminulina* (Schwager)**

The type illustrated by Schwager (1866, p. 256, pl. 7, fig. 112, *vide* Ellis and Messina, 1940, *et seq.*) shows a form with the last chamber distinctly smaller than the penultimate and third chambers combined whereas in *Sphaeroidinella dehiscens subdehiscens* Blow, subsp. nov. the last chamber is approximately equal to the penultimate and third chambers combined. The aperture of Schwager's type is almost symmetrically placed with respect to the suture between the penultimate and third chamber, restricted to the umbilical region, not greatly elongated and without distinctly crenulate margins. It is possible, judging from Schwager's illustration, that the aperture of his form is lipped whilst the sutures seem to be fairly well marked.

Some apparently primitive forms have been observed from the *Globigerinatella insueta* Zone (*s.l.*) (Pl. 12, figs. 74, 75) which appear close indeed to Schwager's type. The features of importance, separating these primitive forms from *Sphaeroidinella dehiscens subdehiscens*, seem to be the rather open and less narrow aperture, absence of distinct crenulate margins and the less embracing chambers.

Further, the aperture in Schwager's type is more nearly restricted to the umbilical area and is not an elongate, rather slitlike opening extending greatly along the suture between the last and earlier chambers as it is in *Sphaeroidinella dehiscens subdehiscens*.

The *Sphaeroidinella seminulina*-*Sphaeroidinella dehiscens* group is complex and still requires further work, but at present the writer feels justified in recognizing two subspecies of *Sphaeroidinella seminulina* although further subdivision of this species may prove to be necessary.

***Sphaeroidinella seminulina seminulina* (Schwager)**

Pl. 12, figs. 74, 75, 76, 77a-c

*Globigerina seminulina* Schwager, 1866, Geol. Theil, Bd. 2, Abt. 2, p. 256, pl. 7, fig. 112 (*vide* Ellis and Messina, 1940 *et. seq.*).

*Globigerina seminulina* Schwager, LeRoy, 1941, Colorado School Mines, Quart., vol. 36, No. 1, pt. 1, p. 44, pl. 3, fig. 108.

*Sphaeroidinella grimsdalei* (Keijzer), Bolli, 1957 (*pars*), U.S. Nat. Mus., Bull., No. 215, p. 114, pl. 26, figs. 8-11, *non* figs. 12a-c.

*Remarks:*—Within the plexus now assigned to this subspecies two generalized groupings can be distinguished. The first "group" is centered around forms similar to that illustrated in figure 75, Plate 12, with forms similar to those illustrated in figures 74 and 76, Plate 12 forming the extremes of variation. The second "group" is centered around forms similar to that illustrated in figures 77a-c but also shows gradation to *Sphaeroidinella seminulina kochi* (Caudri).

In the *Globigerinatella insueta* Zone (*s.l.*) and in the *Globorotalia fohsi barisanensis* Zone the first "group" predominates but does continue to the *Sphaeroidinella seminulina* Zone. Above the *Globorotalia fohsi barisanensis* Zone the second "group" predominates and in the basal part of the *Globorotalia fohsi lobata* Zone forms transitional to *Sphaeroidinella seminulina kochi* appear. Whilst *Sphaeroidinella seminulina kochi* can be considered as quite distinctive with a markedly different stratigraphical range, the two "groups" of *Sphaeroidinella seminulina seminulina* recognized here seem to form a closely interwoven evolving plexus, and the writer does not feel fully justified in making any further taxonomic subdivision. However the second "group" (figures 77a-c, Pl. 12) is

similar to LeRoy's *Sphaeroidinella multiloba* (LeRoy, 1944, pt. 2, p. 91, pl. 4, figs. 7-9) and further work may allow recognition of LeRoy's type as a distinct subspecies of *Sphaeroidinella seminulina* (Schwager). In this connection it is useful to point out that LeRoy (1944, p. 91) stated that his type might "represent a more matured phase of *Globigerina seminulina* Schwager". Bolli (1957, p. 114) pointed out that during the course of evolution the tests of this species tend to become larger and the last whorl may consist of three or four chambers. However, the forms mentioned by Bolli as having five or six chambers are now referred to *Sphaeroidinella seminulina kochi*. In addition to the trends noted by Bolli, there seems to be a further trend wherein the chambers become more inflated and better separated whilst the coiling becomes more lax. It is emphasized, however, that both "groups" are present in sediments above the *Globorotalia fohsi barisanensis* Zone and that *Sphaeroidinella dehiscens subdehiscens* Blow, subsp. nov. appears to develop from the first "group" in the uppermost part of the *Globorotalia fohsi robusta* Zone. Figure 73, Plate 12, illustrates a form which appears to be transitional between the two forms.

*Hypotype*:—From sample, No. RM 19820, auger line near Pozón, eastern Falcón; Plate 12, figures 77a-c, deposited in U.S.N.M. collection, No. 625727. (Other illustrated specimens also deposited in U.S.N.M.)

*Occurrence*:—Ranges from the upper part of the *Globigerina-tella insueta*/*Globigerinoides triloba* Subzone to the top of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

***Sphaeroidinella seminulina kochi* (Caudri)**

Pl. 12, figs. 78, 79

*Globigerina* sp. Koch, 1923, Bericht. Schweiz. Pal. Ges., vol. 18, p. 355, text-figs. 8a-b (*vide* Ellis and Messina, 1940 *et seq.*).

*Globigerina kochi* Caudri, 1934, "Tertiary deposits of Soemba", p. 144. (*vide* Ellis and Messina, 1940 *et seq.*).

*Sphaeroidinella kochi* (Caudri), Glaessner, 1943, Roy. Soc. Victoria, Proc., vol. 55 (new ser.), pt. 1, p. 69 (list).

*Sphaeroidinella grimsdali* (Keijzer), Bolli, 1957 (*pars*), U.S. Nat. Mus. Bull. 215, p. 114, pl. 26, figs. 12a-c, *non* figs. 8-11.

*Remarks*:—This subspecies is distinguished from *Sphaeroidinella seminulina seminulina* (Schwager) by having five or six

(occasionally seven) chambers in the last whorl, a more open umbilicus, a fairly strongly arched aperture and well-separated chambers which tend to be distinctly elongated radially. The test wall in this subspecies tends to be less thick but appears to be composed of the three layers discussed previously.

*Hypotype*:—From sample, No. RM 19507, auger line near Pozón, eastern Falcón; Plate 12, figure 79, deposited in U.S.N.M. collection, No. 625729. Figure 78, deposited in U.S.N.M. collection, No. 626046.

*Occurrence*:—Ranges from the lower part of the *Globorotalia fohsi lobata* Zone to the upper part of the *Sphaeroidinella seminulina* Zone, Pozón formation.

#### Subfamily ORBULININAE

##### Genus **BIORBULINA** Blow, 1956

In this genus the penultimate (not the ultimate) chamber embraces the earlier part of the test whilst at least some of the apertures are areal.

##### **Biorbulina bilobata** (d'Orbigny)

Pl. 13, figs. 80, 81

*Globigerina bilobata* d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne (Autriche), p. 164, pl. 9, figs. 11-14, (*vide* Ellis and Messina, 1940 *et seq.*).

*Biorbulina bilobata* (d'Orbigny), Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 69, text-fig. 2, no. 16.

*Hypotype*:—From sample, No. RM 19304, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626047. (Figures 80, 81, Plate 13, reproduced from Blow, 1956, text-fig. 2, No. 16, and text-fig. 3, respectively).

*Occurrence*:—Ranges from the upper part of the *Globigerinata* *insueta*/*Globigerinoides bispherica* Subzone to the *Globigerina bulloides* Zone, Pozón formation.

##### Genus **ORBULINA** d'Orbigny, 1839

Blow (1956) emended the original diagnosis of *Orbulina* to include only those forms in which the last chamber either completely or almost completely embraces the earlier part of the test and where, at least, some of the apertural pores are areal in position.

***Orbulina suturalis* Bronnimann**

Pl. 13, figs. 82a-b

*Orbulina suturalis* Bronnimann, 1951 (*pars*), Cushman Found. Foram. Res., Contr., vol. 2, pt. 4, p. 135, text-fig. 2, Nos. 1-2, 5-8, 10; text-fig. 3, nos. 3-8, 11, 13-16, 18, 20-22; text-fig. 4, Nos. 2-4, 7-12, 15-16, 19-22.

*Orbulina suturalis* Bronnimann, Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 66, text-fig. 2, Nos. 5-7.

*Orbulina suturalis* Bronnimann, Bolli, 1957, U. S. Nat. Mus., Bull., No. 215, p. 115, pl. 27, fig. 4.

*Remarks:*—The last chamber does not quite completely envelop all the earlier chambers and some of the apertural pores may still be in the sutural positions.

*Hypotype:*—From sample, No. RM 19304, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626048. (Figures 82a-b, Plate 13, reproduced from Blow, 1956, text-fig. 2, Nos. 6-7.)

*Occurrence:*—Ranges from the uppermost part of the *Globiginatella insueta*/*Globigerinoides bispherica* Subzone to the *Globigerina bulloides* Zone, Pozón formation.

***Orbulina universa* d'Orbigny**

Pl. 13, fig. 83

*Orbulina universa* d'Orbigny, 1839, "Foraminifères", in de la Sagra Histoire physique, politique et naturelle de l'île de Cuba, p. 2, pl. 1, fig. 1 (*fide* Ellis and Messina, 1940 *et seq.*).

*Orbulina universa* d'Orbigny, Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 66, text-fig. 2, Nos. 8-9.

*Remarks:*—In this species the last chamber completely envelops the earlier part of the test. The apertures are distributed irregularly over the area of the last chamber, but in some advanced forms the apertural pores seem to be absent and the minute perforations then appear to take over the functions of the apertural pores.

*Hypotype:*—From sample, No. RM 19304, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626049. (Figure 83, Plate 13, reproduced from Blow, 1956, text-fig. 2, No. 9.)

*Occurrence:*—Ranges from the uppermost part of the *Globiginatella insueta*/*Globigerinoides bispherica* Subzone to the *Globigerina bulloides* Zone, Pozón formation.

Genus **PORTICULASPHAERA** Bolli, Loeblich, and Tappan, 1957

The type species of this genus is the short-lived middle Eocene

form *Globigerina mexicana* Cushman but the generic definition given by Bolli, Loeblich, and Tappan (1957) also seems to fit the species previously described by the writer (Blow, 1956) as *Globigerinoides glomerosa* and *Globigerinoides transitoria*. These species are short-lived Miocene forms and there is no genetic relationship with the middle Eocene *Porticulasphaera mexicana* (Cushman). Bolli (1957, p. 115) remarked that it may be expected that further comparative studies will reveal morphological differences which may allow the distinction of the species named by the writer as a separate genus. In this connection the validity of *Candorbulina* Jedlitschka, 1934 needs further investigation.

The writer agrees with Bolli (1957) that "*glomerosa*" and "*transitoria*" should be removed from the genus *Globigerinoides* Cushman, 1927, since they do not have a distinct primary umbilical aperture or open umbilicus in the adult. Further, these species cannot be included in the genera *Orbulina* d'Orbigny, 1839 or *Biorbulina* Blow, 1956 since none of the apertures are areal in position but are all confined to the sutures.

The forms described below are considered ancestral to *Orbulina* and *Biorbulina* and reference is made to Blow (1956) for description of species and subspecies as well as a discussion of evolutionary trends.

#### ***Porticulasphaera glomerosa* (Blow)**

***Porticulasphaera glomerosa curva* (Blow)**

Pl. 13, figs. 84a-b

*Globigerinoides glomerosa curva* Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 64, text-fig. 1, Nos. 9-14.

*Porticulasphaera glomerosa curva* (Blow), Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 115, pl. 27, fig. 7.

*Remarks:*—This subspecies shows the last chamber embracing between 40 and 70 percent of the earlier test and with four to eight slitlike apertures present in the suture between the last and earlier chambers.

*Hypotype:*—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626050. (Figures 84a-b, Plate 13, holotype, reproduced from Blow, 1956, text-fig. 1, Nos. 10, 11.)

*Occurrence:*—Ranges from the middle part of the *Globigerin-*

*atella insueta*/*Globigerinoides bispherica* Subzone to the basal part of the *Globorotalia fohsi barisanensis* Zone, Pozón formation.

**Porticulasphaera glomerosa glomerosa** (Blow) Pl. 14, figs. 85a-b

*Globigerinoides glomerosa glomerosa* Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 65, text-fig. 1, Nos. 15-19; text-fig. 2, Nos. 1-2.

*Porticulasphaera glomerosa glomerosa* (Blow), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 115, pl. 27, fig. 8.

**Remarks:**—This subspecies shows the last chamber embracing more than 75 percent of the earlier test and with numerous slitlike (not rounded) apertures in the suture between the last and earlier chambers.

**Hypotype:**—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626051. (Figures 85a-b, Plate 14, holotype, reproduced from Blow, 1956, text-fig. 1, Nos. 18-19.)

**Occurrence:**—Ranges from the upper part of the *Globigerin-atella insueta*/*Globigerinoides bispherica* Subzone to the basal part of the *Globorotalia fohsi barisanensis* Zone, Pozón formation.

**Porticulasphaera glomerosa circularis** (Blow) Pl. 14, figs. 86a-b

*Globigerinoides glomerosa circularis* Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 65, text-fig. 2, Nos. 3, 4.

*Porticulasphaera glomerosa circularis* (Blow), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 115, pl. 27, fig. 2.

**Remarks:**—This form differs from *Orbulina suturalis* Bronnmann in that all the apertural pores are confined to the sutural positions.

**Hypotype:**—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626052. (Figures 86a-b, Plate 14, holotype, reproduced from Blow, 1956, text-fig. 2, Nos. 3, 4.)

**Occurrence:**—Ranges from the upper part of the *Globigerin-atella insueta*/*Globigerinoides bispherica* Subzone to the middle part of the *Globorotalia fohsi barisanensis* Zone, Pozón formation.

**Porticulasphaera transitoria** (Blow) Pl. 14, figs. 87a-b

*Globigerinoides transitoria* Blow, 1956, Micropaleontology, vol. 2, No. 1, p. 65, text-fig. 2, Nos. 12-15.

*Porticulasphaera transitoria* (Blow), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 115, pl. 27, fig. 3.

*Remarks:*—This species differs from *Porticulasphaera glomerosa* (Blow) in that it is the penultimate chamber which embraces the earlier test and not the ultimate chamber as in *Porticulasphaera glomerosa*. The apertures are short discrete slits confined to the sutural positions.

*Hypotype:*—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626053. (Figures 87a-b, Plate 14, holotype, reproduced from Blow, 1956, text-fig. 2, Nos. 12, 13.)

*Occurrence:*—Ranges from the middle to the upper part of the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, Pozón formation.

#### Subfamily CATAPSYDRACINAE

Genus **CATAPSYDRAX** Bolli, Loeblich, and Tappan, 1957

This genus shows a characteristic bulla which covers the primary aperture and the umbilical part of the test. The infralaminar apertures are large and unrestricted, but sometimes have thin lips or thickened margins.

**Catapsydrax dissimilis** (Cushman and Bermudez) Pl. 12, figs. 88a-c, 89, 90

*Globigerina dissimilis* Cushman and Bermudez, 1937, Cushman Lab. Foram. Res., Contr., vol. 13, pt. 1, p. 25, pl. 3, figs. 4-6 (*fide* Ellis and Messina, 1940 *et seq.*).

*Catapsydrax dissimilis* (Cushman and Bermudez), Bolli, Loeblich, and Tappan, 1957, U.S. Nat. Mus., Bull. No. 215, p. 36, pl. 7, figs. 6-8.

*Catapsydrax dissimilis* (Cushman and Bermudez), Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 116.

*Remarks:*—This species shows a bulla of variable size, normally with three infralaminar apertures. One such aperture occurs at one end of the bulla, the two others at the other end; the margins surrounding these infralaminar apertures are normally thickened. The chambers are generally inflated.

*Hypotype:*—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; Plate 12, figures 88a-c, deposited in U.S.N.M. collection, No. 626054. Other figured specimens also deposited in U.S. National Museum.

*Occurrence:*—Ranges from the base of the Pozón-El Mene

Road section to the top of the *Catapsydrax stainforthi* Zone, To-cuyo formation.

**Catapsydrax stainforthi** Bolli, Loeblich, and Tappan

Pl. 14, figs. 91a-c, 92, 93

*Catapsydrax stainforthi* Bolli, Loeblich, and Tappan, 1957, U.S. Nat. Mus., Bull. No. 215, p. 37, pl. 7, figs. 11a-c.

*Catapsydrax stainforthi* Bolli, Loeblich, and Tappan, Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 116.

*Remarks:*—This species typically shows four moderately inflated chambers in the last whorl; the bulla then has four infralaminar apertures supported on tubelike extensions of the bulla along the sutural depressions between the primary chambers. The infralaminar apertures have small but distinctive lips. Occasionally five primary chambers occur in the last whorl; in these cases (figure 93, Plate 14), the bulla shows a corresponding number of infralaminar apertures.

*Hypotype:*—From sample, No. RM 19152, auger line near Pozón, eastern Falcón; Plate 14, figures 91a-c, deposited in U.S.N.M. collection, No. 626056. Other figured specimens deposited in U.S. National Museum.

*Occurrence:*—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) almost to the top of the *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, To-cuyo formation.

**Catapsydrax unicavus** Bolli, Loeblich, and Tappan      Pl. 15, figs. 94a-c

*Catapsydrax unicavus* Bolli, Loeblich, and Tappan, 1957, U.S. Nat. Mus., Bull. No. 215, p. 37, pl. 7, figs. 9a-c.

*Catapsydrax unicavus* Bolli, Loeblich, and Tappan, Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 116.

*Remarks:*—This species shows a single infralaminar aperture, the peripheral part of the bulla being closed. The chambers are depressed and rather more embracing than in *Catapsydrax dissimilis* (Cushman and Bermudez).

*Hypotype:*—From sample, No. RM 19117, auger line near Pozón, eastern Falcón; Plate 15, figures 94a-c, deposited in U.S.N.M. collection, No. 626058.

*Occurrence:*—Ranges from the base of the Pozón-El Mene

Road section to the top of the *Catapsydrax stainforthi* Zone, Tucuyo formation.

Genus **GLOBIGERINATELLA** Cushman and Stainforth, 1945

**Globigerinatella insueta** Cushman and Stainforth

Pl. 15, figs. 95, 96, 97, 98

*Globigerinatella insueta* Cushman and Stainforth, 1945, Cushman Lab. Foram. Res., Spec. Publ. 14, p. 69, pl. 13, figs. 7-9.

*Globigerinatella insueta* Cushman and Stainforth, Bronnimann, 1950, Cushman Found. Foram. Res., Contr., vol. 1, pts. 3-4, pp. 80-82, pl. 13, figs. 1-12; pl. 14, figs. 1-13.

*Remarks:*—Reference is made to the remarks regarding the possible origin of this monotypic genus and to Bronnimann (1950) who has discussed the morphology of this species in detail.

In addition to the morphological types described by Bronnimann (1950), some specimens of this form show what appears to be a large "primary bulla" which has areal and/or infralaminar apertures; these in turn may be covered by "pustule-like" or "collar-like" secondary bullae.

Figure 97, Plate 15, illustrates a form with uncovered areal apertures in the primary bulla but also having "secondary bullae" covering the infralaminar apertures along the contact suture of the "primary bulla" and the true primary chambers. Figure 98 illustrates a form with "areal pustules" ("secondary bullae") covering the areal apertures of the large primary bulla. This form also has "collar-like" secondary bullae covering the infralaminar apertures of the primary bullae; these collar-like secondary bullae also extend along the sutures of the true primary chambers.

It is not always readily apparent whether or not the "final chamber" should be considered as a bulla or a true primary chamber since areal apertures also occur in the primary chambers of earlier ontogenetic stages (see figure 96, Plate 15; also Bronnimann, 1950); but the wall structure of the "final chamber" in some specimens suggest that they are, in fact, large and much inflated bullae.

*Hypotype:*—From sample, No. RM 19188, auger line near Pozón, eastern Falcón; Plate 15, figure 98, deposited in U.S.N.M. collection, No. 626059. Figure 95, Plate 15, from sample, No. RM

19117, also deposited in U.S.N.M. collection, No. 626061.

*Occurrence*:—Ranges from the base of the *Catapsydrax stainforthi* Zone to the top of the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, Tocuyo and Pozón formations.

Genus **GLOBIGERINITA** Bronnimann, 1951

***Globigerinita naparimaensis*** Bronnimann

***Globigerinita naparimaensis naparimaensis*** Bronnimann Pl. 15, figs. 99a-c

*Globigerinita naparimaensis* Bronnimann, 1951, Cushman Found. Foram. Res., Contr., vol. II, pt. 1, p. 18, text-figs. 1-14.

*Remarks*:—*Globigerinita naparimaensis naparimaensis* is distinguished from *Globigerinita naparimaensis incrusta* (Akers) by its possession of infralaminar apertures along the contact suture of the bulla with the primary chambers as well as its having infralaminar apertures in line with the sutures of the primary chambers. The bulla of this subspecies is more inflated and often embraces more of the primary chambers than in *Globigerinita naparimaensis incrusta*.

*Hypotype*:—From sample. No. RM 19304, auger line near Pozón, eastern Falcón; Plate 15, figures 99a-c, deposited in U.S.N.M. collection, No. 626062.

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the top of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

***Globigerinita naparimaensis incrusta*** (Akers) Pl. 15, figs. 100, 101

*Globigerinita incrusta*, Akers, 1955, Jour. Pal., vol. 29, No. 4, p. 655, pl. 65, figs. 2a-2d.

*Remarks*:—Aker's species is regarded as being closely related to *Globigerinita naparimaensis* Bronnimann, and since there appears to be complete gradation between the two forms, it is considered that Aker's type is best placed as a subspecies of *Globigerinita naparimaensis*.

During the examination of the samples from the Pozón-El Mene Road section it was found that samples from a particular but fairly short interval often had a predominance of either *Globigerinita naparimaensis naparimaensis* or *Globigerinita naparimaen-*

*sis incrusta* with a corresponding reduction in the prevalence of the other subspecies. This relative abundance is then often reversed in succeeding or preceding intervals. Furthermore, some intervals show forms apparently transitional from *Globigerina juvenilis* Bolli to *Globigerinita naparimaensis incrusta* but in other intervals these transitional forms are either absent or scarce. From these observations it may be considered that a repetitive and heterochronous derivation of *Globigerinita* seems likely (see Text-fig. 4).

*Globigerinita naparimaensis incrusta* is distinguished from *Globigerinita naparimaensis naparimaensis* by the absence of infralaminar apertures not in line with the sutures of the primary chambers, a less inflated and embracing bulla which sometimes shows short tubelike extensions along the sutures of the primary chambers. This subspecies has a generally smaller overall test size.

Figure 101, Plate 15, illustrates a form which appears transitional to *Globigerina juvenilis* where it seems that the apertural lip of this latter species has become attached to the ventral surface of the opposing chamber. It seems that the distinction between *Globigerinita* and *Globigerina juvenilis* is best made where the "apertural lip" shows definite attachment to the opposing chamber and the ends of the bulla so-formed are restricted.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate No., figure 100, deposited in U.S.N.M. collection, No. 625723. (Figure 101, Plate 15, from same sample, also deposited in U.S.N.M. collection.)

*Occurrence*:—Ranges from the *Catapsydrax stainforthi* Zone to the lower part of the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

#### Genus **GLOBIGERINOITA** Bronnimann, 1952

**Globigerinoita morugaensis** Bronnimann

Pl. 15, figs. 102a-c

*Globigerinoita morugaensis* Bronnimann, 1952, Cushman Found. Foram. Res., Contr., vol. III, pt. 1, p. 26, text-fig. 1, figs. a-m; text-fig. 2, figs. a-h.

*Globigerinoita morugaensis* Bronnimann, Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 116.

*Hypotype*:—From sample, No. RM 19697, auger line near Pozón, eastern Falcón; Plate 15, figures 102a-c, deposited in U.S.N.M. collection, No. 626064.

*Occurrence*:—Ranges from the middle part of the *Globorotalia mayeri*/*Globorotalia linguaensis* Subzone to the middle part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

Genus **GLOBOROTALOIDES** Bolli, 1957

This genus shows a *Globorotalia*-like early stage which is followed by a *Globigerina*-like intermediate stage and a final *Catapsydrax*-like stage wherein a bulla-like chamber partly or completely covers the umbilical part of the earlier test. It appears that the intermediate stage may be omitted in some cases and the early *Globorotalia*-like stage is followed immediately by the stage with the bulla-like final chamber.

**Globorotaloides variabilis** Bolli

Pl. 16, figs. 103 a-c, 104, 105

*Globorotaloides variabilis* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 117, pl. 27, figs. 15a-20c.

*Remarks*:—The specimens illustrated in figures 104 and 105, Plate 16, and showing the *Globigerina*-like and *Globorotalia*-like stages respectively, were dissected (Blow, 1955) from forms similar to that illustrated in figures 103a-c, Plate 16, and possessing a bulla-like final chamber.

*Hypotype*:—From sample, No. RM 19697, auger line near Pozón, eastern Falcón; Plate 16, figures 103a-c, deposited in U.S.N.M. collection, No. 626066. (Figures 104, 105, Plate 16, also deposited in U.S.N.M. collection.)

*Occurrence*:—Typical specimens range from the middle part the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone to the middle part of the *Sphaeroidinella seminulina* Zone, Pozón formation. Occasional immature and poorly preserved forms occur in the *Catapsydrax stainforthi* Zone and in the *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, which are only tentatively referred to this species but which may possibly be referable to *Globorotaloides suteri* Bolli.

Family **GLOBOROTALIIDAE**

Subfamily **GLOBOROTALIINAE**

Genus **GLOBOROTALIA** Cushman, 1927

**Globorotalia acostaensis** Blow, sp. nov.

Pl. 17, figs. 106a-c, 107

?*Globigerina dutertrei* Wiseman and Ovey (*non* d'Orbigny), 1950, Geol. Assoc., Proc., vol. 61, p. 65, pl. 2, figs. 1a-c.

*Diagnosis of species:*—Test low trochospiral; spire opening regularly but fairly rapidly, with 11-13 chambers composing the spire, usually with 5-6 chambers in the last whorl. Equatorial periphery strongly lobate, with the test appearing subcircular in equatorial profile; axial periphery rounded with the test appearing thick and parallel-sided in side view; chambers ovate or subspherical, generally inflated but not well separated; often the last chamber is much reduced in size compared with its predecessor, and it also occasionally becomes somewhat displaced towards the umbilical side (fig. 107, Pl. 17). Spiral side slightly convex, almost flat, or occasionally slightly concave due to the inflated nature of the chambers of the last whorl. Umbilical side generally slightly convex, with a small but usually deep umbilicus; sutures of the spiral and umbilical sides radial, depressed; aperture interiomarginal, umbilical-extraumbilical, arched, with a distinctive lip. Maximum diameter of holotype, 0.36 mm.

*Remarks:*—This form differs from *Globorotalia mayeri* Cushman and Ellisor in having more inflated chambers, a thicker test, completely radial sutures, a more distinctive apertural lip, and a more rapidly opening spire. It differs from *Globorotalia opima continua* Blow, subsp. nov. in having more numerous and more inflated chambers in the last whorl, although transitional forms occur in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone (lower part). It differs from *Globigerina dutertrei* d'Orbigny in having less globular and less well-separated chambers. The aperture of *Globigerina dutertrei* appears to be umbilical only in D'Orbigny's figures. The specimen figured by Wiseman and Ovey as *Globigerina dutertrei* (1950, pl. 2, figs. 1a-c) shows an interiomarginal, umbilical-extraumbilical aperture with a distinct lip, and the writer believes this specimen to be identical with *Globorotalia acostaensis*.

*Globorotalia acostaensis* first appears after the extinction of *Globorotalia mayeri*.

*Holotype:*—From sample, No. RM 19791, auger line near Pozón, eastern Falcón; Plate 17, figures 106 a-c, deposited in U.S.N.M. collection, 625707.

*Occurrence:*—Ranges from the *Globorotalia menardii men-*

*ardii*/*Globigerina nepenthes* Zone to the *Globigerina bulloides* Zone, Pozón formation.

***Globorotalia birnageae* Blow, sp. nov.**

Pl. 17, figs. 108a-c

*Diagnosis of species*.—Test low trochospiral; spire opening regularly but fairly slowly, with usually six chambers in the last whorl; equatorial profile almost circular; equatorial periphery slightly lobate; axial periphery rounded, with the test appearing rather parallel-sided in side view; chambers slightly elongated tangentially as viewed from the spiral side, not inflated, but usually embracing; last chamber often smaller than its predecessor; spiral side flat to slightly convex; umbilical side slightly convex; sutures of the spiral side curved, slightly depressed; sutures of the umbilical side radial, slightly depressed, sometimes rather indistinct; umbilicus, small, often completely closed; aperture slitlike with a distinctive lip, interiomarginal, umbilical-extraumbilical; wall calcareous, finely perforate; maximum diameter of holotype, 0.22 mm.

*Remarks*.—This species differs from *Globorotalia kugleri* Bolli in having less deeply incised sutures, rather tangentially elongated chambers, a closed or almost closed umbilicus, fewer chambers in the last whorl, and a less highly arched aperture which has a more distinctive lip. It differs from *Goborotalia mayeri* Cushman and Ellis in being consistently much smaller in size, in the closed (or almost closed) umbilicus, and also in having slightly more tangentially elongated chambers as seen from the spiral side. It differs from *Globorotalia opima continuosa* Blow, subsp. nov. in having more chambers in the last whorl. It also differs from *Globorotalia fohsi barisanensis* (LeRoy) in having a more circular outline and a less convex (not vaulted) umbilical side.

The species is named after Miss G. N. Birnage, Librarian of the Palaeontological Department, The British Petroleum Company Limited, London, in recognition of her assistance in compiling this work.

*Holotype*.—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 17, figures 108a-c, deposited in U.S.N.M. collection, No. 625709.

*Occurrence*;—Ranges from the uppermost part of the *Globigerinatella insueta*/*Globigerinoides triloba* Subzone to the basal part of the *Globorotalia fohsi barisanensis* Zone, Tocuyo and Pozón formations.

***Globorotalia* cf. *canariensis* (d'Orbigny)**

Pl. 17, figs. 109a-c

cf. *Rotalina canariensis* d'Orbigny, 1839, Foraminifères des îles Canaries, in Barker-Webb and Berthelot, Hist. nat. des îles Canaries, vol. 2, pt. 2, (Zool.), p. 130, pl. 1, figs. 34-36. (Fide Ellis and Messina, 1940 *et seq.*).

*Remarks*:—In the upper part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone some forms which otherwise closely resemble *Globorotalia scitula scitula* (Brady) develop thin but distinctive keels. These forms are tentatively referred to D'Orbigny's species, which is described as being depressed and carinate throughout. Concomitant with the development of the keel, the test appears to become rather more depressed than in typical *Globorotalia scitula scitula*. However, the writer's specimens are small compared with Recent specimens of *Globorotalia canariensis* (d'Orbigny) and are generally less lobate. No forms referable to the species described by D'Orbigny have been observed by the writer below the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, and it is possible that the writer's specimens may represent early forms of typical *Globorotalia canariensis*. Maximum diameter observed, 0.27 mm.

*Hypotype*:—From sample, No. RM 19804, auger line near Pozón, eastern Falcón; Plate 17, figures 109a-c, deposited in U.S.N.M. collection, No. 626068.

*Occurrence*:—Scarce and only observed from the uppermost part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone to the *Globigerina bulloides* Zone, Pozón formation.

***Globorotalia fohsi* Cushman and Ellis**

Reference is made to the work of Bolli (1950) for a description of the subspecies and also for a complete discussion of the evolutionary inter-relationship between the various subspecies.

**Globorotalia fohsi barisanensis** (LeRoy)

Pl. 17, figs. 110, 111a-c

*Globorotalia barisanensis* LeRoy, 1939, *Natuurk. Tijdschr. Nederl. Indië*, vol. 99, pt. 6, p. 265, pl. 1, figs. 8-10 (*vide* Ellis and Messina, 1940 *et seq.*).

*Globorotalia fohsi barisanensis* LeRoy, Bolli, 1950, *Cushman Found. Foram. Res., Contr.*, vol. 1, pts. 3 and 4, p. 88, pl. 15, figs. 6a-c.

*Globorotalia fohsi barisanensis* LeRoy, Bolli, 1957, *U. S. Nat. Mus., Bull.* No. 215, p. 119, pl. 28, figs. 8a-c.

*Remarks:*—Within the *Catapsydrax stainforthi* Zone and in the *Globigerinatella insueta* Zone (*s.l.*) this subspecies shows a generally lobate equatorial periphery, and has fairly deeply incised sutures on the spiral side (Pl. 17, fig. 110). In the *Globorotalia fohsi barisanensis* Zone it has a less lobate periphery, less deeply incised sutures, and a more definitely vaulted umbilical side.

*Hypotype:*—From sample, No. RM 19304, auger line near Pozón, eastern Falcón; Plate 17, figures 111a-c, deposited in U.S.N.M. collection, No. 626069. Figure 110, Plate 17 from sample No. RM 19188, also deposited in U.S.N.M. collection, No. 626071.

*Occurrence:*—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the basal part of the *Globorotalia fohsi fohsi* Zone, Tocuyo and Pozón formations.

**Globorotalia fohsi fohsi** Cushman and Ellisor

Pl. 17, figs. 112a-c

*Globorotalia fohsi* Cushman and Ellisor, 1939, *Cushman Lab. Foram. Res., Contr.*, vol. 15, p. 12, pl. 2, figs. 6a-c (*vide* Ellis and Messina, 1940 *et seq.*).

*Globorotalia fohsi* Cushman and Ellisor, Renz, 1948, *Geol. Soc. Amer., Mem.* 32, p. 137, pl. XI, figs. 2a-c.

*Globorotalia fohsi fohsi* Cushman and Ellisor, Bolli, 1950, *Cushman Found. Foram. Res., Contr.*, vol. 1, pts. 3 and 4, p. 88, pl. 15, figs. 4a-c.

*Globorotalia fohsi fohsi* Cushman and Ellisor, Bolli, 1957, *U.S. Nat. Mus., Bull.* No. 215, p. 119, pl. 28, figs. 9a-10c.

*Remarks:*—This subspecies shows an acute but not keeled peripheral margin, although some peripheral thickening may occur; the umbilical side is vaulted, and the sutures of the spiral side are not incised.

*Hypotype:*—From sample, No. RM 19367, auger line near Pozón, eastern Falcón; Plate 17, figures 112a-c, deposited in U.S.N.M. collection, No. 626072.

*Occurrence:*—Ranges from the base of the *Globorotalia fohsi*

*fohsi* Zone to the basal part of the *Globorotalia fohsi lobata* Zone, Pozón formation.

***Globorotalia fohsi lobata* (Bermudez)**

Pl. 16, figs. 113a-c

*Globorotalia lobata* Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. 25, p. 286, pl. 22, figs. 9-11.

*Globorotalia fohsi lobata* Bermudez, Bolli, 1950, Cushman Found. Foram. Res., Contr., vol. 1, pts. 3 and 4, p. 88, pl. 15, figs. 7-8c.

*Globorotalia fohsi lobata* Bermudez, Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 119, pl. 28, figs. 13a-14b.

*Remarks:*—This subspecies shows a “cocks-comb” appearance of the last few chambers which typically also possess a fairly strong keel. Some peripheral thickening may also occur on the earlier chambers which, however, do not possess a keel.

*Hypotype:*—From sample, No. RM 19426, auger line near Pozón, eastern Falcón; Plate 16, figures 113a-c, deposited in U.S.N.M. collection, No. 626074.

*Occurrence:*—Ranges from the base of the *Globorotalia fohsi lobata* Zone to the basal part of the *Globorotalia fohsi robusta* Zone, Pozón formation.

***Globorotalia fohsi robusta* Bolli**

Pl. 16, figs. 114a-c

*Globorotalia fohsi robusta* Bolli, 1950, Cushman Found. Foram. Res., Contr., vol. 1, pts. 3 and 4, p. 89, pl. 15, figs. 3a-c.

*Globorotalia fohsi robusta* Bolli, Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 119, pl. 28, figs. 16a-c.

*Remarks:*—This subspecies is carinate throughout, but the strength of the keel is variable; in some late forms the keel is massive with much secondary peripheral thickening.

*Hypotype:*—From sample, No. RM 19470, auger line near Pozón, eastern Falcón; Plate 16, figures 114a-c, deposited in U.S.N.M. collection, No. 626076.

*Occurrence:*—Restricted to the *Globorotalia fohsi robusta* Zone, Pozón formation.

***Globorotalia linguaensis* Bolli**

Pl. 17, figs. 115a-c

*Globorotalia linguaensis* Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 120, pl. 29, figs. 5a-c.

*Remarks:*—This species is distinguished from *Globorotalia minima* (Akers) by the less convex umbilical side and the more

circular equatorial profile; the spire opens less rapidly than in Akers' species. The aperture is longer in *Globorotalia linguaensis* and extends further towards the periphery than in *Globorotalia minima*. Some later forms of *Globorotalia linguaensis* show a faint keel. Maximum diameter of hypotype, 0.3 mm.

*Hypotype*:—From sample, No. RM 19507, auger line near Pozón, eastern Falcón; Plate 17, figures 115a-c, deposited in U.S.N.M. collection, No. 626078.

*Occurrence*:—Ranges from the uppermost part of the *Globorotalia fohsi robusta* Zone to the top of the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Globorotalia mayeri* Cushman and Ellisor**

Pl. 18, figs. 116a-c

*Globorotalia mayeri* Cushman and Ellisor, 1939, Cushman Lab. Foram. Res., Contr., vol. 15, pt. 1, p. 11, pl. 2, figs. 4a-c (*vide* Ellis and Messina, 1940 *et seq.*).

*Globorotalia mayeri* Cushman and Ellisor, Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 118, pl. 28, figs. 4a-c.

*Remarks*:—*Globorotalia mayeri* Cushman and Ellisor differs from *Globorotalia acostaensis* Blow, sp. nov. in having slightly curved or sinuous sutures on the spiral side, less inflated and narrower chambers, as well as a thinner test.

*Hypotype*:—From sample, No. RM 19188, auger line near Pozón, eastern Falcón; Plate 18, figures 116a-c, deposited in U.S.N.M. collection, No. 626080.

*Occurrence*:—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the top of the *Globorotalia mayeri* Zone, Pozón formation.

***Globorotalia menardii* (d'Orbigny)**

***Globorotalia menardii archeomenardii* (Bolli)**

Pl. 18, figs. 117a-c

*Globorotalia archeomenardii* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 119, pl. 28, figs. 11a-c.

*Remarks*:—Bolli's type is here considered as a subspecies of *Globorotalia menardii* (d'Orbigny). It is distinguished from *Globorotalia menardii praemenardii* (Cushman and Stainforth) by the strongly convex spiral side and the rather angular rhomboidal shape of the chambers as seen in side view. In early forms of this subspecies from the *Globigerinatella insueta*/*Globigerinoides bis-*

*spherica* Subzone a keel seems to be present only on the last few chambers, although some peripheral thickening may be present on the earlier chambers. Also, in these early forms, the chambers are rather elongate tangentially and the writer considers it likely that this form developed from *Globorotalia scitula praescitula* Blow, subsp. nov. In the uppermost part of the *Globorotalia fohsi barisanensis* Zone, forms transitional to *Globorotalia menardii praemenardii* occur.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; Plate 18, figures 117a-c, deposited in U.S.N.M. collection, No. 626082.

*Occurrence*:—Ranges from the base of the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone to the basal part of the *Globorotalia fohsi fohsi* Zone, Tucuyo and Pozón formation.

***Globorotalia menardii praemenardii* (Cushman and Stainforth)**

Pl. 18, figs. 118a-c

*Globorotalia praemenardii* Cushman and Stainforth, 1945, Cushman Lab. Foram. Res., Spec. Pub. 14, p. 70, pl. 13, fig. 14.

*Globorotalia praemenardii* Cushman and Stainforth, Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 120, pl. 29, figs. 4a-c.

*Remarks*:—This form is distinguished from *Globorotalia menardii menardii* (d'Orbigny) by the absence of distinctly limbate and raised sutures on the spiral side and also by the more equally biconvex test. It is distinguished from *Globorotalia menardii archiomenardii* (Bolli) by the more lobate equatorial periphery and the less convex spiral side. Forms transitional to *Globorotalia menardii menardii* (d'Orbigny) occur in the middle part of the *Globorotalia fohsi robusta* Zone.

*Hypotype*:—From sample, No. RM 19367, auger line near Pozón, eastern Falcón; Plate 18, figures 118a-c, deposited in U.S.N.M. collection, No. 626084.

*Occurrence*:—Ranges from the base of the *Globorotalia fohsi fohsi* Zone to the upper part of the *Globorotalia fohsi robusta* Zone, Pozón formation.

***Globorotalia menardii menardii* (d'Orbigny)** Pl. 18, figs. 119a-c, 120a-c

*Rotalia* ("Rotalie") *menardii* d'Orbigny, 1826, Ann. Sci. Nat., Paris, sér. 1, vol. 7, p. 273, Modèles No. 10 (*fide* Ellis and Messina, 1940 *et seq.*).

*Globorotalia menardii* (d'Orbigny), Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 120, pl. 29, figs. 6a-10b.

*Remarks:*—The form described by D'Orbigny in 1826 is here regarded as being the "central type" for a closely related series of forms which show gradual evolutionary changes. Although this subspecies shows a considerable variation in size, characters such as the distinctive keel, slightly convex spiral side and the only moderately convex umbilical side are common features. The writer distinguishes this subspecies from *Globorotalia menardii praemenardii* (Cushman and Stainforth) by the presence of a stronger keel and the distinctly limbate, often raised sutures on the spiral side.

Both the spiral and umbilical sides are less convex in this subspecies than in *Globorotalia menardii praemenardii*.

*Hypotype:*—From sample, No. RM 19507, auger line near Pozón, eastern Falcón; Plate 18, figures 120a-c, deposited in U.S.N.M. collection, No. 626086. Figures 119a-c, from sample, No. RM 19470, also deposited in U.S.N.M. collection, No. 626087.

*Occurrence:*—Ranges from the middle part of the *Globorotalia fohsi robusta* Zone to the top of the Pozón formation. It persists to the present time.

***Globorotalia menardii miocenica* Palmer**

Pl. 19, figs. 121a-c

*Globorotalia menardii miocenica* Palmer, 1945, Bull. Amer. Pal., vol. 29, No. 115, p. 70, pl. 1, fig. 10.

*Remarks:*—This subspecies differs from *Globorotalia menardii menardii* (d'Orbigny) in having a strongly vaulted umbilical side, an almost flat spiral side, a weaker keel, and less limbate sutures. The maximum and minimum diameters of the test are distinctly unequal so that the test of this form appears elongate in equatorial profile.

*Hypotype:*—From sample, No. RM 19791, auger line near Pozón, eastern Falcón; Plate 19, figures 121a-c, deposited in U.S.N.M. collection, No. 626088.

*Occurrence:*—Forms transitional from *Globorotalia menardii menardii* (d'Orbigny) occur in the uppermost part *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, but typical specimens

occur rarely only in the *Sphaeroidinella seminulina* Zone, Pozón formation.

**Globorotalia minima** (Akers)

Pl. 19, figs. 122a-c

*Globorotalia canariensis* (d'Orbigny) var. *minima* Akers, 1955, Jour. Pal., vol. 29, No. 4, p. 659, pl. 65, figs. 3a-3d.

Akers (1955) referred his variety to *Globorotalia canariensis* (d'Orbigny) but merely remarked that his variety differs from D'Orbigny's species in being smaller in size. Akers' figures show a form with a fairly vaulted umbilical side and a rounded to subacute, not keeled, periphery, whereas D'Orbigny's species has a depressed test with a well-marked keel. Examination of samples from eastern Falcón shows that Akers' variety should be considered as a distinct species. Since Akers did not give a description of his type, a description based on specimens from Pozón is given here. These Pozón specimens compare excellently with the figures given by Akers.

*Description*:—Test low trochospiral; spire opening rapidly, with usually six chambers in the last convolution. As seen from the spiral side the chambers are almost equally as broad as long with the exception of the last two chambers. The sutures of the spiral side are not much depressed and are moderately curved. The sutures of the umbilical side are slightly sinuous to almost radial. Equatorial periphery only slightly lobate; axial periphery rounded to subacute, not keeled; aperture interiomarginal, umbilical-extraumbilical, a low arch with a thin short lip; umbilicus small or closed; wall calcareous, finely perforate; maximum diameter of hypotype, 0.28 mm.

*Remarks*:—The size and morphology of the specimens from the Pozón-El Mene Road section compare excellently with Akers' figures. Akers gave 0.22 mm. as the maximum diameter of his holotype which is about the average for the specimens observed by the writer. This species may be ancestral to *Globorotalia linguaensis* Bolli.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; Plate 19, figures 122a-c, deposited in U.S.N.M. collection, No. 625725.

*Occurrence*:—Ranges from the *Globigerinatella insueta*/*Globigerinoides bisphérica* Subzone to the *Globorotalia fohsi robusta* Zone, Pozón formation.

***Globorotalia minutissima* Bolli**

Pl. 19, figs. 123a-c

*Globorotalia minutissima* Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 119, pl. 29, figs. 1a-c.

*Hypotype*:—From sample, No. RM 19304, auger line near Pozón, eastern Falcón; Plate 19, figures 123a-c, deposited in U.S.N.M. collection, No. 626089.

*Occurrence*:—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Globorotalia obesa* Bolli**

Pl. 19, figs. 124a-c

*Globorotalia obesa* Bolli, 1957, U.S. Nat. Mus., Bull., No. 215, p. 119, pl. 29, figs. 2a-3.

*Remarks*:—This species is distinctive by virtue of its highly inflated spherical chambers. The aperture is without either lip or rim. In some specimens showing gerontic features there is an additional chamber which extends somewhat over and on to the spiral side, the aperture becoming nearly interiomarginal, peripheral.

*Hypotype*:—From sample, No. RM 19480, auger line near Pozón, eastern Falcón; Plate 19, figures 124a-c, deposited in U.S.N.M. collection, No. 616091.

*Occurrence*:—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the *Globigerina bulloides* Zone, Pozón formation.

***Globorotalia opima* Bolli**

***Globorotalia opima continnosa* Blow, subsp. nov.**

Pl. 19, figs. 125a-c

*Diagnosis of subspecies*:—Test low trochospiral; spire opening rather rapidly, with four chambers in the last whorl; equatorial periphery lobate; axial periphery rounded, with the test appearing rather parallel-sided in side view; the sutures of the spiral and umbilical sides depressed, radial; chambers ovate to subspherical, but not well separated; umbilicus narrow, deep; aperture with a

distinctive lip, interiomarginal, umbilical-extraumbilical, a comparatively high arch which tends to be somewhat elongate normal to the axis of coiling at the periphery, giving a "coma-shaped" appearance in side view (Plate 19, figure 125c). Wall calcareous rather coarsely perforate; maximum diameter of holotype 0.26 mm.

*Remarks:*—This form differs from *Globorotalia opima nana* Bolli in having ovate or only merely subspherical chambers, a higher arched aperture with a more distinctive apertural lip, and a rather more coarsely perforate wall structure. Forms transitional to *Globorotalia opima nana* occur in the *Catapsydrax stainforthi* Zone, whilst forms transitional to *Globorotalia acostaensis* Blow, sp. nov. occur in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone.

*Holotype:*—From sample, No. RM 19542, auger line near Pozón, eastern Falcón; Plate 19, figures 125a-c, deposited in U.S.N.M. collection, No. 625711.

*Occurrence:*—Ranges from the *Catapsydrax stainforthi* Zone to the *Sphaeroidinella seminulina* Zone, Tocuyo and Pozón formations.

### ***Globorotalia scitula* (Brady)**

***Globorotalia scitula scitula* (Brady)**

Pl. 19, figs. 126a-c

*Pulvinulina scitula* Brady, 1884, Roy. Soc. Edinburgh, Proc., vol. 11, p. 716. Figures in Brady, 1884, Challenger Exped. Rept., Zool., vol. 9, pl. 103, figs. 7a-c.

*Globorotalia canariensis* Cushman and Stainforth (*non* d'Orbigny), 1945, Cushman Lab. Foram. Res., Spec. Pub. 14, p. 70, pl. 13, figs. 12a-c.

*Globorotalia canariensis* Renz (*non* d'Orbigny), 1948, Geol. Soc. Amer., Mem. 32, p. 136, pl. XI, figs. 3a-b.

*Globorotalia scitula* (Brady), Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 120, pl. 29, figs. 11a-12c.

*Description:*—Test low-trochospiral; spire opening fairly rapidly with four to five (occasionally six) chambers in the last whorl; equatorial periphery slightly to moderately lobate; axial periphery subacute to rounded, not keeled; spiral side slightly convex; umbilical side convex to slightly vaulted; the sutures of the spiral side are depressed, sinuous to nearly radial; chambers as seen from the spiral side nearly as broad as long, almost hemispherical; umbilicus small or almost closed, fairly shallow; aperture interiomarginal, umbilical-extraumbilical, with a distinct lip; wall calcareous, finely

perforate, smooth, often appearing glassy; maximum diameter of hypotype, 0.33 mm.

*Remarks*:—This subspecies differs from *Globorotalia scitula praescitula* Blow, subsp. nov. in having almost hemispherical chambers, a less vaulted umbilical side and less deeply incised sutures on the spiral side. The periphery is subacute to rounded as compared with the more acute periphery of *Globorotalia scitula praescitula*. It differs from *Globorotalia scitula gigantea* Blow, subsp. nov. in being smaller and in the almost complete lack of peripheral thickening and ventral pustules.

*Hypotype*:—From sample, No. RM 19367, auger line near Pozón, eastern Falcón; Plate 19, figures 126a-c, deposited in U.S.N.M. collection, No. 626093.

*Occurrence*:—Ranges from the uppermost part of the *Globorotalia fohsi barisanensis* Zone to the *Globigerina bulloides* Zone, Pozón formation. The subspecies persists to Recent.

*Globorotalia scitula gigantea* Blow, subsp. nov.      Pl. 16, figs. 127a-c

*Diagnosis of subspecies*:—Test trochospiral; spire opening fairly rapidly, with four to five chambers in the last whorl. Equatorial periphery lobate; axial periphery rounded to subacute, not keeled but often with much peripheral thickening; test generally biconvex; sutures of the spiral side depressed and strongly curved; sutures of the umbilical side slightly sinuous to radial; chambers almost hemispherical as seen from the spiral side; aperture interior-marginal, umbilical-extraumbilical, a low arch with a distinct lip; wall calcareous, perforate, often with distinct pustules in the umbilical sutural positions and over the umbilical surface of the earlier chambers; maximum diameter of holotype 0.59 mm.

*Remarks*:—In general morphology this subspecies is similar to *Globorotalia scitula scitula* (Brady) but differs in being much larger. Two groups co-exist with mean diameters averaging 0.28 mm. and 0.54 mm. with few specimens greatly departing from the two means; the larger-sized group is assigned to this subspecies and shows the presence of much peripheral thickening and pustules on the umbilical side. The test is also generally more equally biconvex than in *Globorotalia scitula scitula* (Brady).

*Holotype*:—From sample, No. RM 19480, auger line near Pozón, eastern Falcón; Plate 16, figures 127a-c, deposited in U.S.N.M. collection, No. 625715.

*Occurrence*:—Ranges from the upper part of the *Globorotalia fohsi fohsi* Zone to the lower part of the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Globorotalia scitula praescitula*** Blow, subsp. nov. Pl. 19, figs. 128a-c

*Diagnosis of subspecies*:—Test a fairly low trochospiral; spire opening regularly but not rapidly, with four to five chambers in the last whorl; equatorial profile ovate to subcircular; equatorial periphery lobate; axial periphery subacute but not keeled, although some peripheral thickening occurs on the earlier chambers; sutures of the spiral side depressed and strongly curved; sutures of the umbilical side depressed, slightly sinuous to radial; spiral side convex, umbilical side distinctly convex to rather vaulted; chambers longer than broad, elongate tangentially as seen from the spiral side; umbilicus small, sometimes closed, but often fairly deep; aperture interior-marginal, umbilical-extraumbilical, a low arch with a thin lip; wall calcareous, finely perforate, not glassy; maximum diameter of holotype, 0.30 mm.

*Remarks*:—This subspecies differs from *Globorotalia scitula scitula* (Brady) in having more tangentially elongate chambers, a more convex umbilical side, and a less finely perforate wall texture; the periphery is also generally more acute but transitional forms occur in the upper part of the *Globorotalia fohsi barisanensis* Zone.

*Holotype*:—From sample, No. RM 19152, auger line near Pozón, eastern Falcón; Plate 19, figures 128a-c, deposited in U.S.N.M. collection, No. 625713.

*Occurrence*:—Ranges from the base of the Pozón-El Mene Road section (*Catapsydrax stainforthi* Zone) to the top of the *Globorotalia fohsi barisanensis* Zone, Pozón formation.

Genus **HASTIGERINELLA** Cushman, 1927

This genus possesses a lipped interior-marginal, umbilical-extra-

umbilical aperture, at least in the earlier stages (Pl. 16, fig. 130). The typical "club-shaped" and radially elongate chambers do not seem to appear until later ontogenetic stages; the earlier chambers are usually ovate or only slightly radially elongate. Because of the nature and position of the aperture the writer believes that this genus has evolved repeatedly from a *Globorotalia*-like ancestor and not via *Hastigerina* as inferred by Cushman (1950, pl. 27).

In this study the writer notes that *Hastigerinella* appears before *Hastigerina* although both occur in the Miocene.

***Hastigerinella bermudezi* Bolli**

Pl. 16, figs. 129a-b, 130

*Hastiacrinella bermudezi* Bolli, 1957, U.S. Nat. Mus., Bull. No. 215, p. 112, pl. 25, figs. 1a-c.

*Remarks:*—This species shows spherical to ovate early chambers with a distinct *Globorotalia*-like aperture (Pl. 16, fig. 130). The later chambers become club-shaped with the aperture extending on to the periphery. The test is less trochoid than in *Hastigerinella rhumbleri* Galloway, 1933 (= *Hastigerina digitata* Rhumbler, 1911, non *Globigerina digitata* Brady, 1879), and the chambers less elongate. It seems likely that the various *Hastigerinella* species also appear independently from a "globorotalid-stock" since this species has a restricted range and does not appear to be closely related to the typically Recent *Hastigerinella rhumbleri* Galloway.

*Hypotype:*—From sample, No. RM 19290, auger line near Pozón, eastern Falcón; Plate 16, figures 129a-b, deposited in U.S.N.M. collection, No. 626095. (Figure 130, Plate 16 also deposited in U.S.N.M. collection.)

*Occurrence:*—Ranges only from the upper part of the *Globigerinatella insueta* *Globigerinoides bispherica* Subzone to the basal part of the *Globorotalia fohsi fohsi* Zone, Pozón formation.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

***Anomalina alazanensis* Nuttall**

*Anomalina alazanensis* Nuttall, 1932, Jour. Pal., vol. 6, p. 31, pl. 8, figs. 4, 8, 9.

*Hypotype:*—From sample, No. RM 19285, auger line near

Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626097.

*Occurrence*:—Rather rare and seems to be restricted to samples from the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, *Globorotalia fohsi barisanensis* Zone and *Globorotalia fohsi fohsi* Zone, Pozón formation.

#### Genus *ANOMALINOIDES* Brotzen, 1942

##### *Anomalinoides trinitatensis* (Nuttall)

*Truncatulina trinitatensis* Nuttall, 1928, Geol. Soc. London, Quart. Jour., vol. 84, p. 97, pl. 7, figs. 3, 5, 6 (*vide* Ellis and Messina, 1940 *et seq.*).

*Anomalinoides trinitatensis* (Nuttall), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 115, pl. X, figs. 11a-c.

*Remarks*:—This form is rather similar to *Cibicides nucleatus* (Seguenza); however, in *Anomalinoides trinitatensis* the aperture extends much further towards the umbilicus, whereas in *Cibicides nucleatus* the umbilical part of the aperture is confined to the peripheral part of the basal suture of the last chamber.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626098.

*Occurrence*:—Occurs from the *Catapsydrax stainforthi* Zone, Tocuyo formation, to the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation. Often common, especially in the *Globorotalia fohsi fohsi* Zone and in the *Globorotalia mayeri* Zone (*s.l.*).

#### Genus *CIBICIDES* Montfort, 1808

##### *Cibicides americanus* (Cushman)

*Cibicides americanus* (Cushman), Cushman and Cahill, 1933, U.S. Geol. Surv., Prof. Paper 175-A, p. 34, pl. 13, figs. 2a-c (*vide* Ellis and Messina, 1940 *et seq.*).

*Remarks*:—This species is thin-walled and fragile and has a fairly well-marked narrow carina. Aperture on the spiral side has a thin liplike extension. Involute both on the spiral and umbilical sides. It differs from *Cibicides mantaensis* (Galloway and Morrey) in having a narrow carina and slightly depressed sutures.

*Hypotype*:—From sample, No. RM 20104, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626100.

*Occurrence*:—Generally scarce throughout the Pozón formation but becomes relatively common in some impoverished faunas from the topmost part of this formation, *i.e.*, in the upper part of the *Sphaeroidinella seminulina* Zone and *Globigerina bulloides* Zone.

***Cibicides earsteni* Cushman and Ellisor**

*Cibicides earsteni* Cushman and Ellisor, 1939, Cushman Lab. Foram. Res., Contr., vol. 15, p. 13, pl. 2, figs. 8a-c (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19282, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626102.

*Occurrence*:—Fairly common and occurs in the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, *Globorotalia fohsi* "Zone" (*s.l.*), *Globorotalia mayeri* Zone (*s.l.*) and in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Cibicides concentricus* (Cushman)**

*Cibicides concentricus* (Cushman), Cushman, 1930, Florida Geol. Surv., Bull. No. 4, p. 61, pl. 12, fig. 4 (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19522, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626104.

*Occurrence*:—Scarce in the *Globigerinatella insueta* Zone (*s.l.*) and in the *Globorotalia fohsi* "Zone" (*s.l.*) but fairly common in the *Globorotalia mayeri* Zone (*s.l.*) and in the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone. Only observed in isolated samples from the *Sphaeroidinella seminulina* Zone, Pozón formation.

***Cibicides compressus* Cushman and Renz**

*Cibicides floridanus* (Cushman) var. *compressa* Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, pt. 1, p. 26, pl. 4, fig. 9.

*Cibicides compressus* Cushman and Renz, Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 127, pl. X, figs. 9a-c.

*Remarks*:—Renz (1948) considered this form to be sufficiently distinctive from *Cibicides floridanus* Cushman to be considered as a distinct species. The present writer's view is that the species shows little variation, except in size, and, therefore, agrees with Renz's conclusions.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626106.

*Occurrence*:—Often common in samples from the *Globigerinatella insueta* Zone (*s.l.*), *Globorotalia fohsi* "Zone" (*s.l.*) *Globorotalia mayeri* Zone (*s.l.*) and from the *Globorotalia menardii*/*Globigerina nepenthes* Zone, Tocuyo and Pozón formations. Isolated specimens have been observed in the *Sphaeroidinella seminulina* Zone and *Globigerina bulloides* Zone, indicating that its virtual disappearance is due to ecological rather than stratigraphical reasons.

#### ***Cibicides falconensis* Renz**

*Cibicides falconensis* Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 128, pl. XI, figs. 6a-c.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626108.

*Occurrence*:—Fairly common in the *Catapsydrax stainforthi* Zone and *Globigerinoides insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation, but rather scarce or scarce in the *Globigerinatella insueta*/*Globigerinoides bispherica* Subzone, *Globorotalia fohsi* "Zone" (*s.l.*), and lower part of the *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

#### ***Cibicides mantaensis* (Galloway and Morrey)**

*Cibicides mantaensis* (Galloway and Morrey), Hedberg, 1937, Jour. Pal., vol. 11, p. 683, pl. 92, figs. 12a-c.

*Remarks*:—This species is involute both on the spiral and umbilical sides and appears closely related to *Cibicides americanus* Cushman but differs from the latter species in having limbate, slightly raised sutures. The part of the aperture on the spiral side is covered by a small liplike plate.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626110.

*Occurrence*:—Fairly common in the *Catapsydrax stainforthi* Zone, *Globigerinatella insueta*/*Globigerinoides triloba* Subzone, Tocuyo formation; also in the *Globigerinatella insueta*/*Globigerinoides*

*bispherica* Subzone and *Globorotalia foshi* "Zone" (*s.l.*), Pozón formation.

***Cibicides matanzasensis* (Hadley)**

*Cibicides matanzasensis* (Hadley), Palmer, 1941, Soc. cubana hist. nat., Mem., vol. 15, p. 295, pl. 28, figs. 6a-c.

*Remarks*:—The part of the aperture on the spiral side of this species is not clearly marked. Spiral side evolute but strongly involute umbilically. Sutures meet the periphery nearly at right-angles and are raised. Chambers numerous, about 12-14 in the last whorl only slowly increasing in size as added.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626112.

*Occurrence*:—Generally scarce in all zones below the *Globorotalia menardii menardii*/*Globigerina nepenthes* Zone, Pozón formation.

***Cibicides perlucida* Nuttall**

*Cibicides perlucida* Nuttall, 1932, Jour. Pal., vol. 6, p. 33, pl. 8, figs. 10-12.

*Remarks*:—Umbilical side strongly vaulted; spiral side slightly convex with the sutures rather indistinct and strongly oblique to the periphery.

*Hypotype*:—From sample. No. RM 19117, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626114.

*Occurrence*:—Scarce and only observed in isolated samples from the *Catapsydrax stainforthi* Zone, Tocuyo formation.

Genus **LATICARININA** Galloway and Wissler, 1927

***Laticarinina pauperata* (Parker and Jones)**

*Laticarinina pauperata* (Parker and Jones), Cushman, 1931, U.S. Nat. Mus., Bull. No. 104, pt. 8, p. 114, pl. 20, fig. 4; pl. 21, fig. 1 (*vide* Ellis and Messina, 1940 *et. seq.*).

*Remarks*:—This distinctive form, with its wide peripheral flange and generally compressed test, has been considered as a planktonic species. Its association with predominantly deepwater mainly planktonic assemblages supports this view; however, Cush-

man suggested that it may be pseudoplanktonic, being attached to floating seaweed.

*Hypotype*:—From sample, No. RM 19280, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626115.

*Occurrence*:—Occurs, but is scarce, in the *Catapsydrax stainforthi* Zone and *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations. Occasional specimens have been observed in mainly planktonic assemblages from the *Globorotalia fohsi* "Zone" (*s.l.*), Pozón formation.

#### Genus **PLANULINA** d'Orbigny, 1826

##### **Planulina dohertyi** (Galloway and Morrey)

*Cibicides dohertyi* Galloway and Morrey, 1929, Bull. Amer. Pal., vol. 15, No. 55, p. 39, pl. 4, figs. 7a-c.

*Planulina dohertyi* (Galloway and Morrey), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 150, pl. X, figs. 6a-b.

*Hypotype*:—From sample, No. RM 19255, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626117.

*Occurrence*:—Scarce and only observed in isolated samples from the *Globigerinatella insueta* Zone (*s.l.*) and *Globorotalia fohsi* "Zone" (*s.l.*), Tocuyo and Pozón formations.

##### **Planulina marialana** Hadley

*Planulina marialana* Hadley, 1934, Bull. Amer. Pal., vol. 20, No. 70A, p. 27 pl. 4, figs. 4-7 (*vide* Renz, 1948).

*Hypotype*:—From sample, No. RM 19210, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626119.

*Occurrence*:—Scarce and only observed in samples from the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

##### **Planulina mexicana** Cushman

*Planulina mexicana* Cushman, 1927, Cushman Lab. Foram. Res., Contr., vol. 3, p. 113, pl. 23, figs. 5a-b (*vide* Ellis and Messina, 1940 *et seq.*).

*Hypotype*:—From sample, No. RM 19181, auger line near Pozón, eastern Falcón; deposited in U.S.N.M. collection, No. 626121.

*Occurrence*:—Generally scarce but observed in the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations, also in the *Globorotalia fohsi* "Zone" (*s.l.*), and *Globorotalia mayeri* Zone (*s.l.*), Pozón formation.

**Planulina subtenuissima** (Nuttall)

*Anomalina subtenuissima* Nuttall, 1928, Geol. Soc. London, Quart. Journ., vol. 84, p. 100, pl. 7, figs. 13, 15, text-fig. 6 (*vide* Renz, 1948).

*Planulina subtenuissima* (Nuttall), Renz, 1948, Geol. Soc. Amer., Mem. 32, p. 151, pl. XI, figs. 4a-b.

*Hypotype*:—From sample, No. RM 19285, auger line near Pozón; eastern Falcón; deposited in U.S.N.M. collection, No. 626123.

*Occurrence*:—Generally scarce and only observed in the *Globigerinatella insueta* Zone (*s.l.*), Tocuyo and Pozón formations.

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## APPENDIX I

NOTE ON THE VALIDITY OF THE NAME "SAN LORENZO  
FORMATION", DISTRICT OF ACOSTA,  
EASTERN FALCÓN, VENEZUELA

In a private letter, dated 12th August, 1957, Dr. H. G. Kugler drew the writer's attention to certain facts concerning the validity of the term "San Lorenzo formation" as applied to certain beds which lie between the Pozón and Guacharaca formations in the District of Acosta, State of Falcón, Venezuela. Unfortunately, Dr. Kugler's most valuable comments only reached the writer after the present study had been finalized and all the charts draughted.

In his letter, Dr. Kugler referred to the following statements concerning a valid formational name in southern California, U.S.A., i.e., San Lorenzo formation. "Oligocene": southern California (Santa Cruz Mountains region).

(a) R. Arnold (1906, U.S. Geol. Surv., Prof. Paper 47, p. 16) stated, 'San Lorenzo formation. Essentially a series of grayish "muddy" shales and fine sandstones, typically exposed along the bed of the San Lorenzo River about 2 miles above Boulder Creek, Santa Cruz County. Extends W. from type locality in Big Basin, on N. side of which it rests conformably against older yellowish sandstones of Butano Ridge, possibly Oligocene in age.' This statement

by Arnold was later slightly modified by Atwill as follows:

(b) E. R. Atwill (1935, Amer. Assoc. Petr. Geol., Bull., vol. 19, no 8, p. 1204) stated, "Recent work points to the conclusion type San Lorenzo may range from Oligocene (or even Eocene) to Miocene."

(c) R. A. Liddle (1928, The geology of Venezuela and Trinidad, p. 397, stated, "Upper Oligocene shales, sandstones and limestones included in the Agua Clara, Quiros, El Mene, Curamichate, La Planchada and Tocuyo horizons constitute the major producing horizon of western and north-western Venezuela".

Dr. Kugler pointed out that the "Tocuyo horizon" of Liddle (1928) is obviously synonymous with A. Senn's (1935) "El Mene sand formation". Renz (1948, p. 9) rightly abandoned the term "El Mene sand formation" because of its inadequate definition as well as its preoccupation by such terms as El Mene de Buchivacoa and Barinas (see also Hedberg, 1938). However, it appears that a mistake was made in introducing the term "San Lorenzo formation" without having first consulted the Stratigraphic Lexicon.

Dr. Kugler goes on to say in his letter, "In view of these statements by Arnold and Atwill on a valid formation, I recommend you to drop the term "San Lorenzo formation" and introduce the term "*Tocuyo formation*". According to the "Lexico estratigrafico de Venezuela" (1956) the term "Tocuyo" has not been used for any formation or member.

Following these comments and the recommendations by Dr. Kugler, the writer proposes that the term "Tocuyo formation" should be substituted for the term "San Lorenzo formation", District of Acosta, State of Falcón, Venezuela.

The writer wishes to express his sincere appreciation for Dr. Kugler's comments and for permission to quote from his letter of the 12th August, 1957.

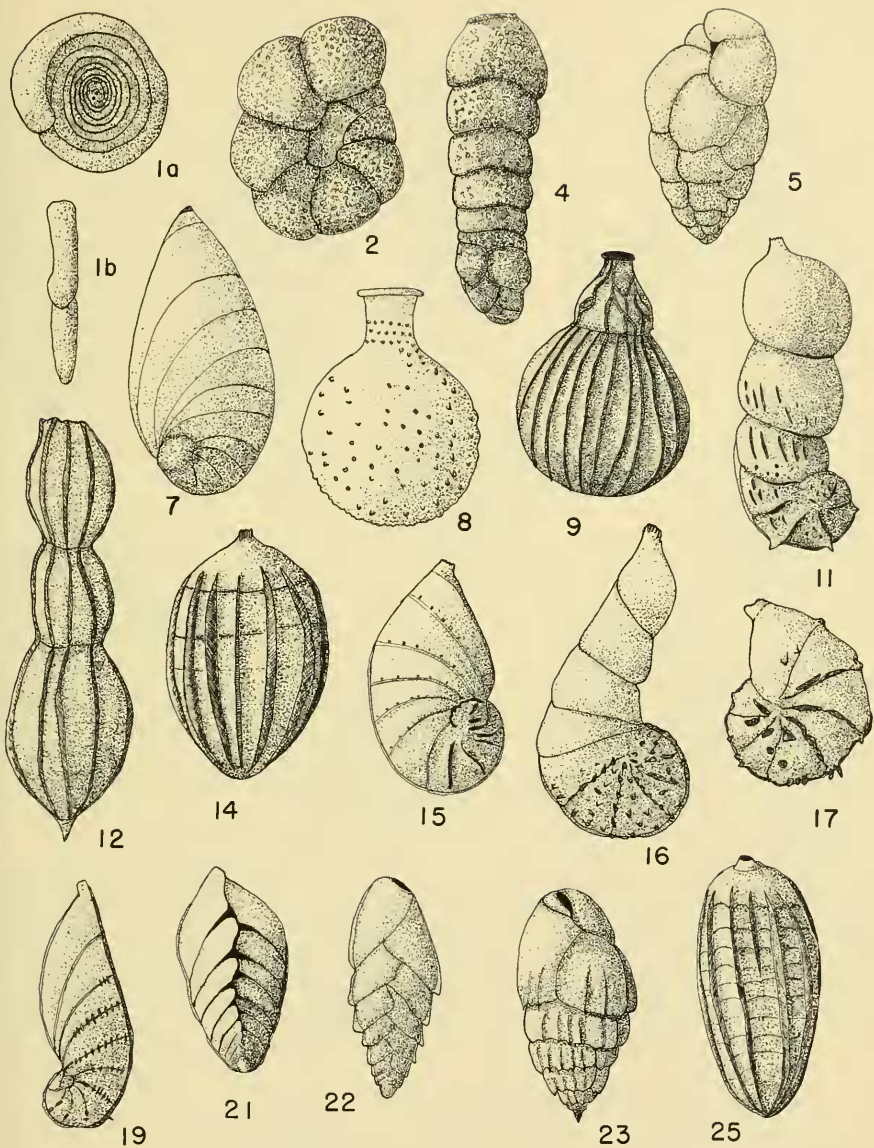


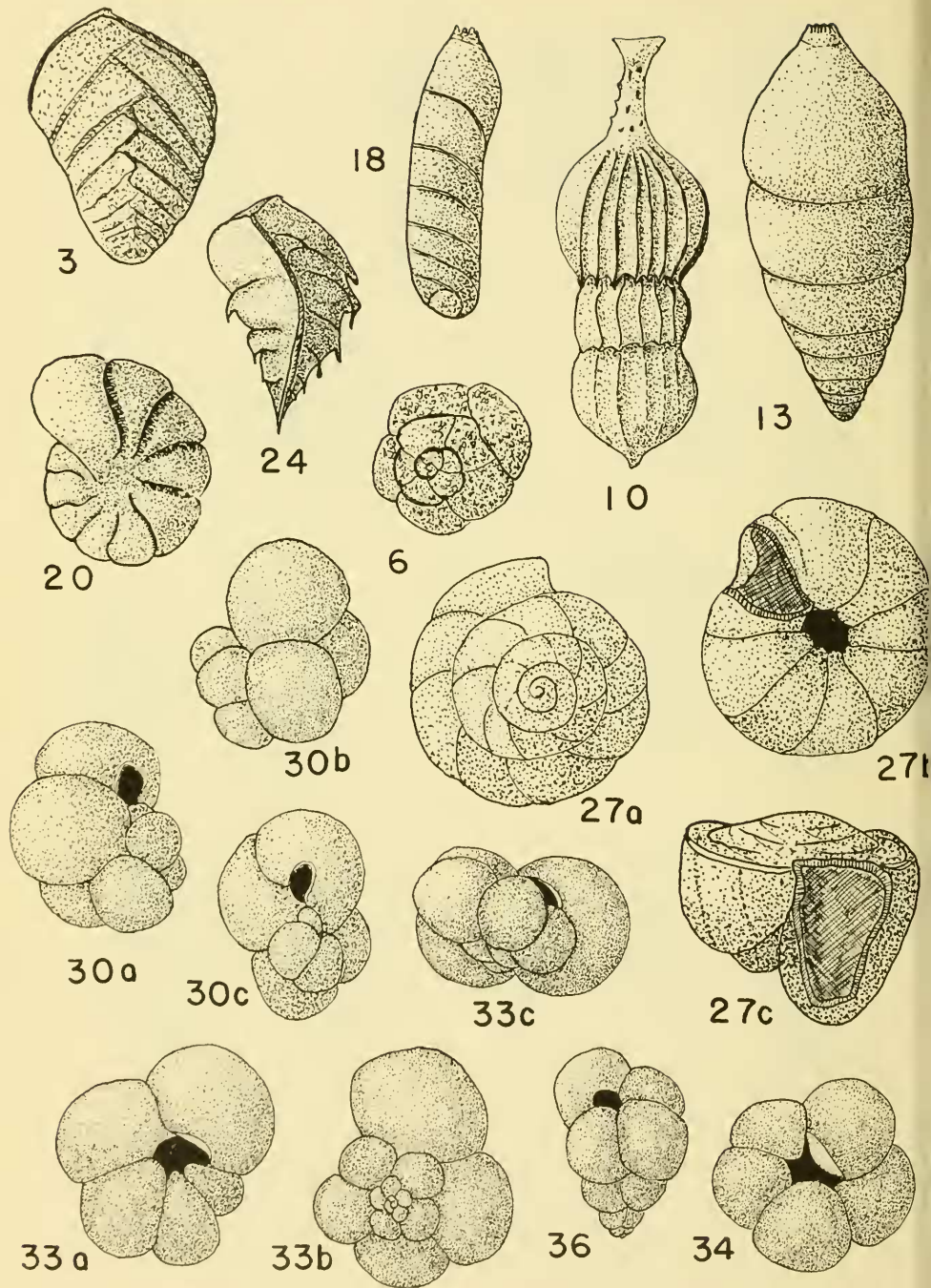
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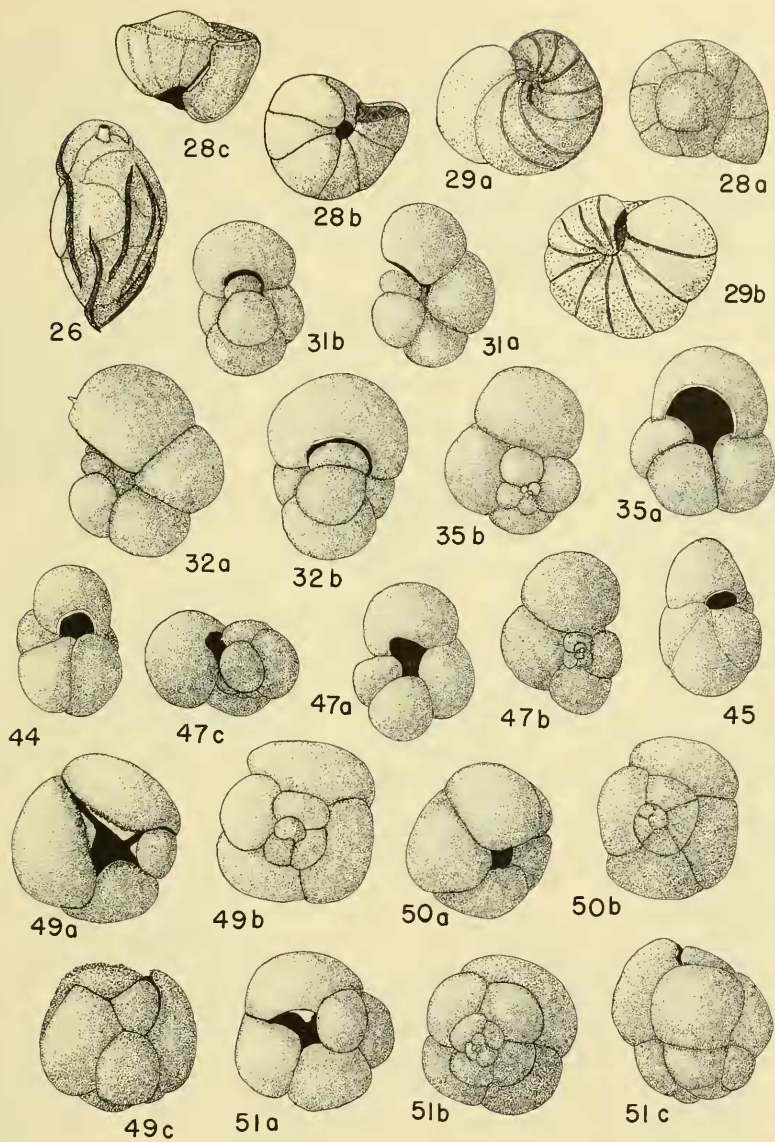
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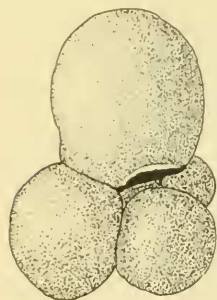
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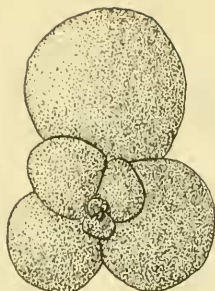
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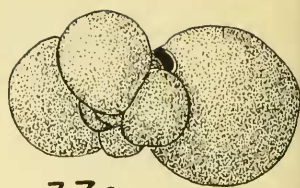




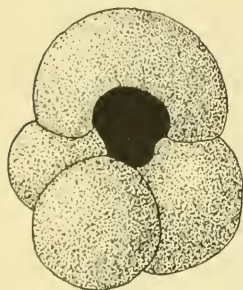
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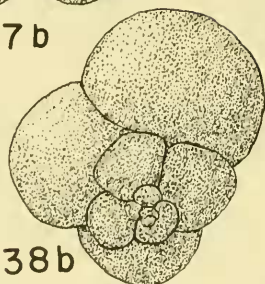
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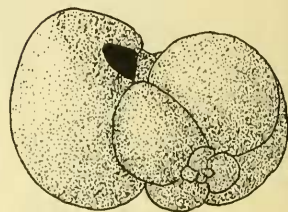
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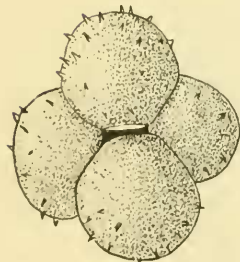
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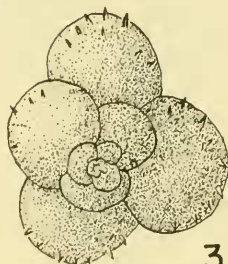
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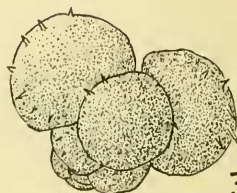
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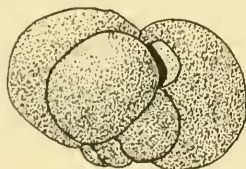
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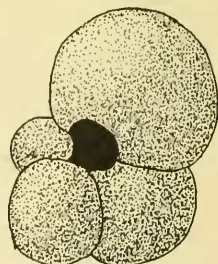
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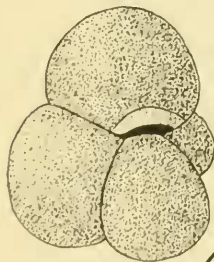
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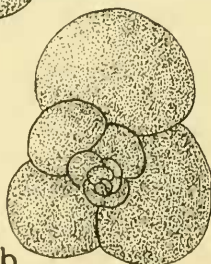
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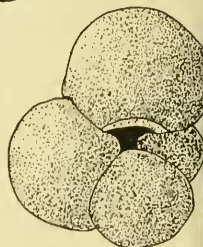
48



40a



40b



41

Explanation of Plate 9

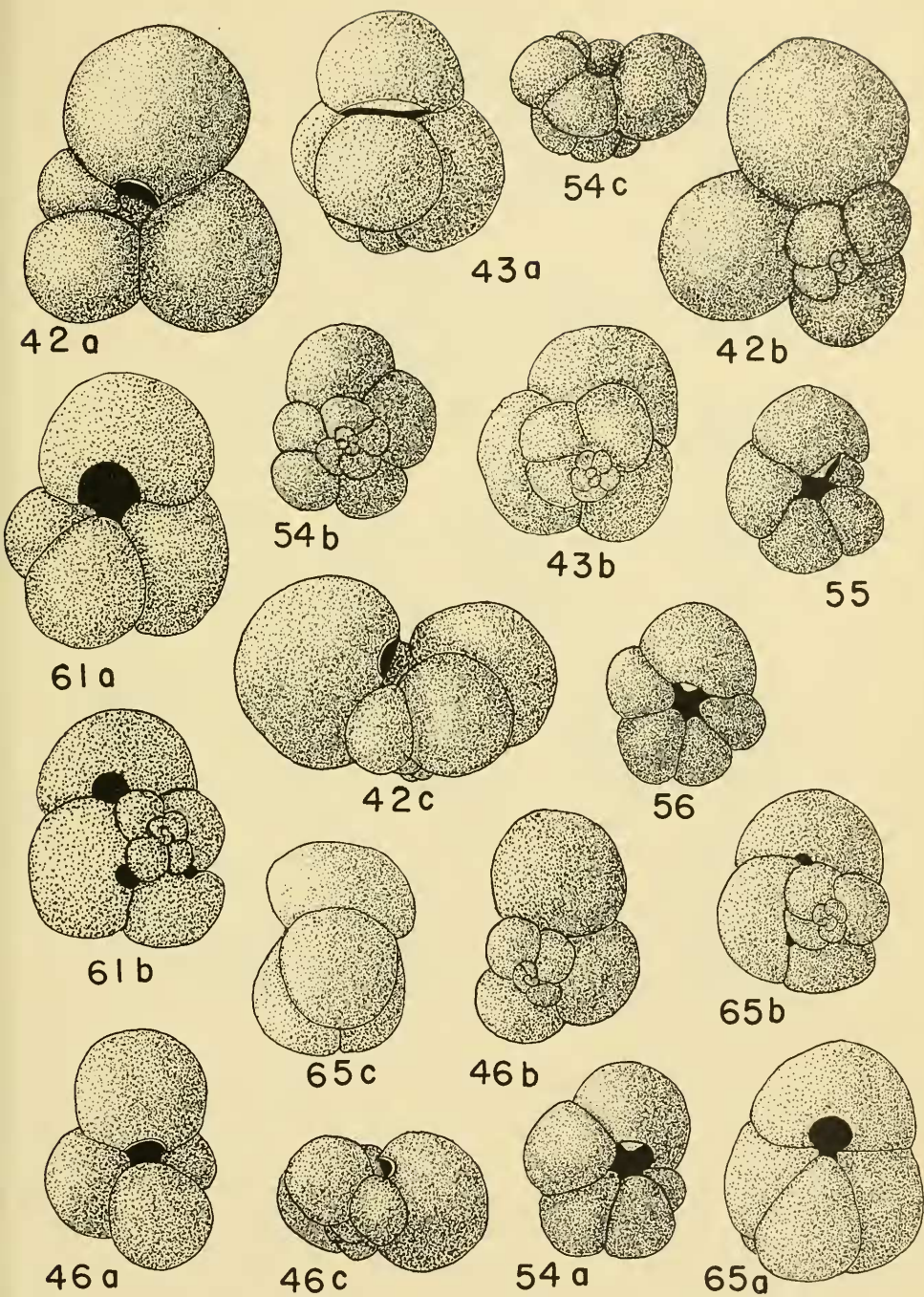
(For figures 42, 43, 46 see Plate 10; figures 44, 45, 47 see Plate 8)

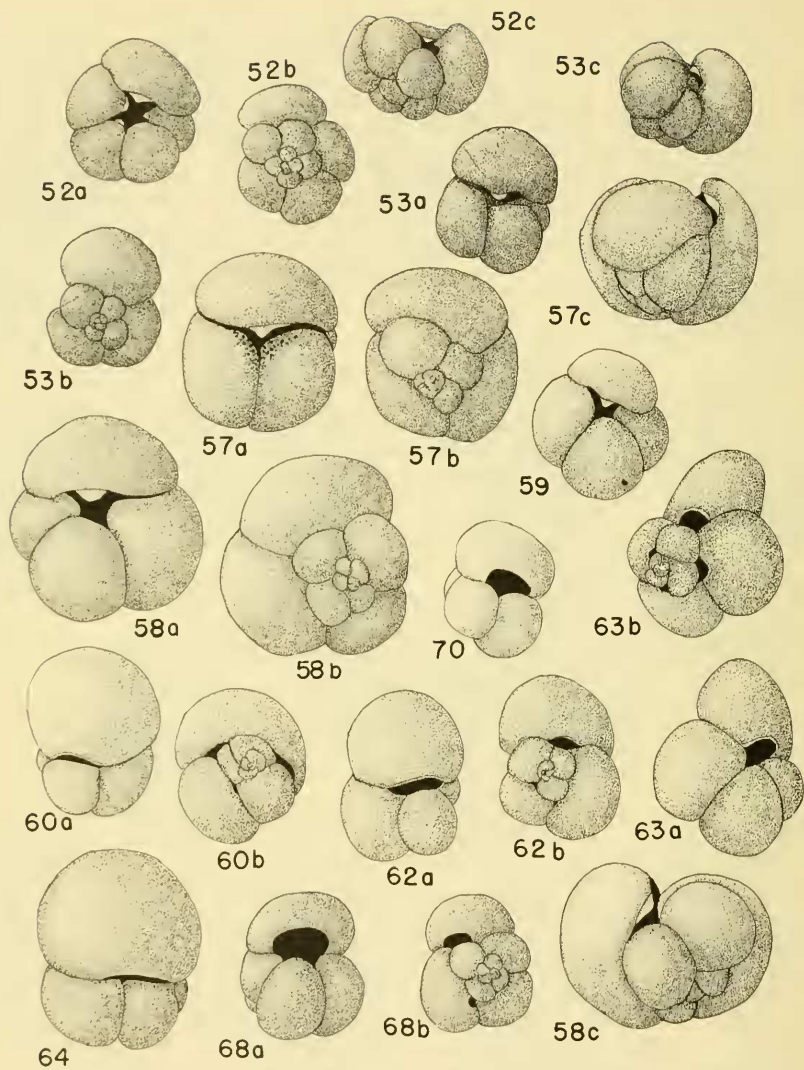
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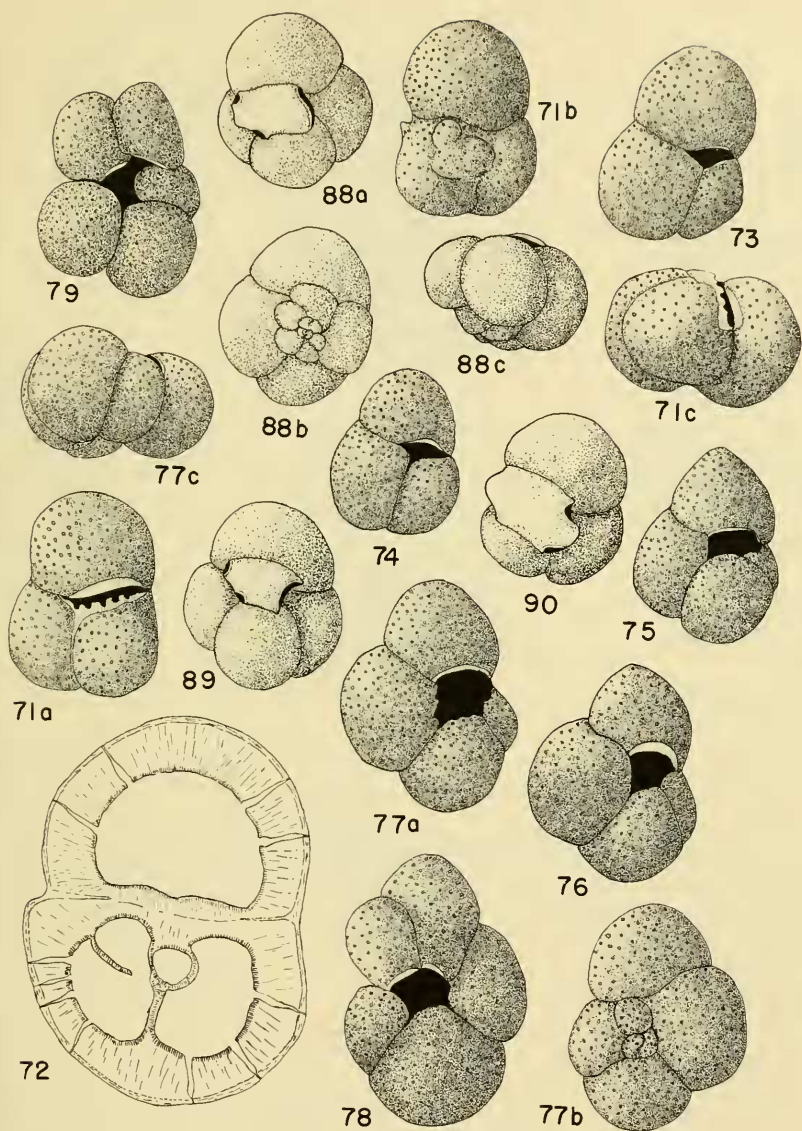
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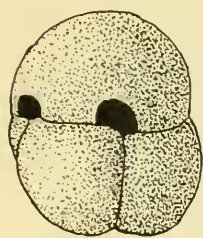
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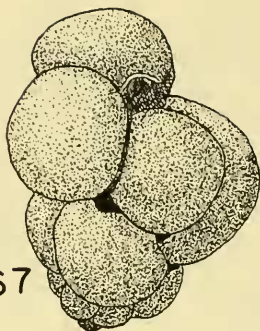
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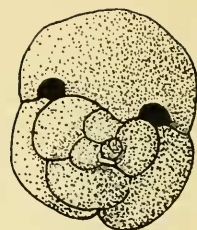




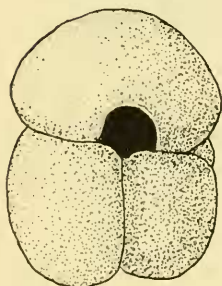
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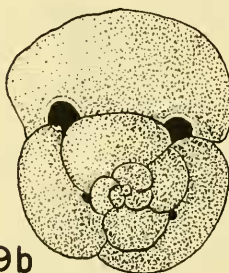
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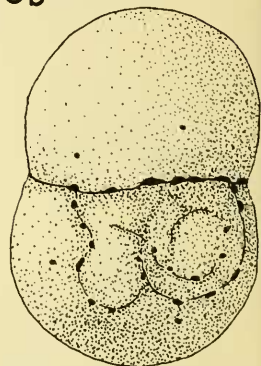
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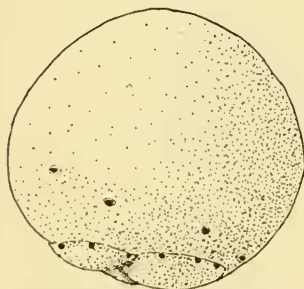
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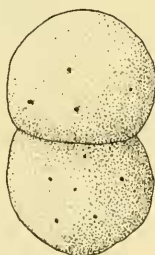
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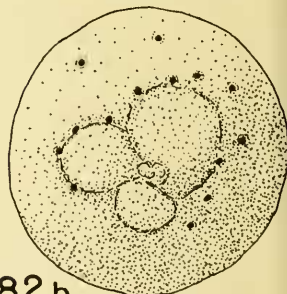
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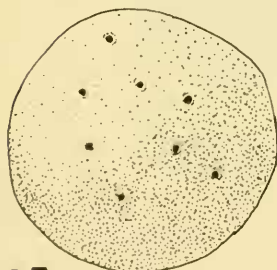
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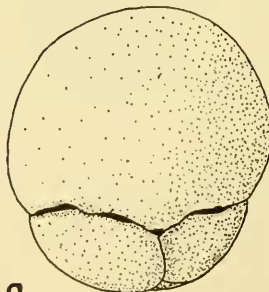
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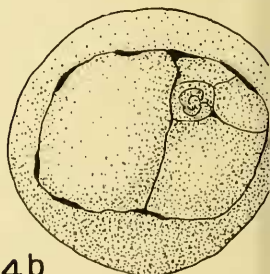
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83



84a



84b

## Explanation of Plate 13

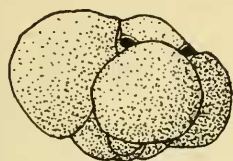
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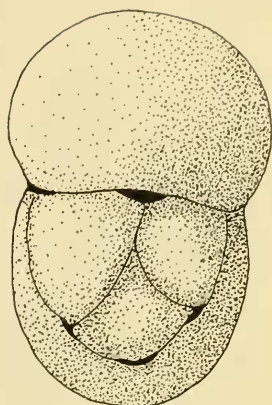
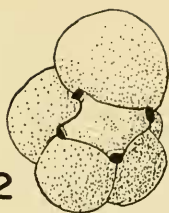
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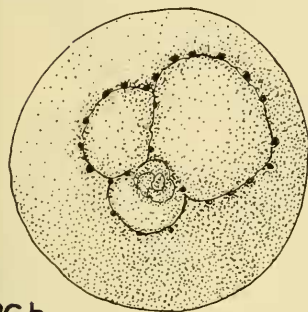


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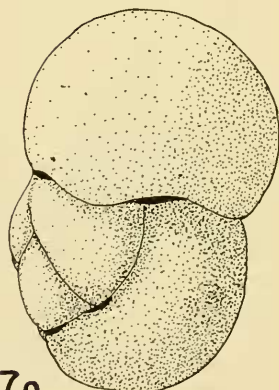
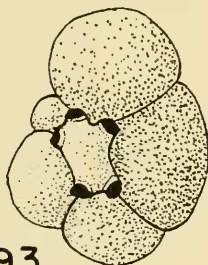


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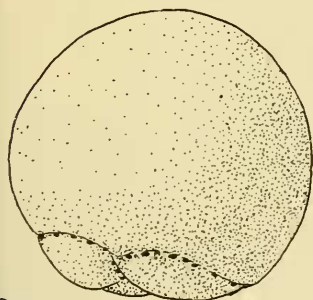


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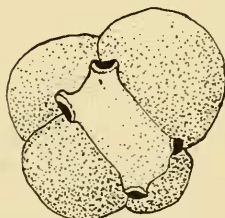
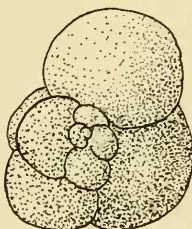


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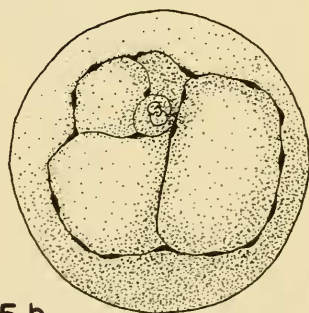


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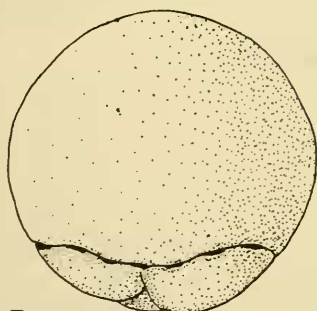
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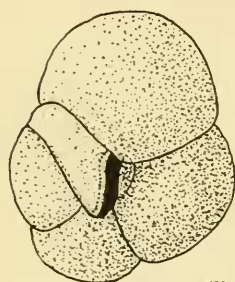
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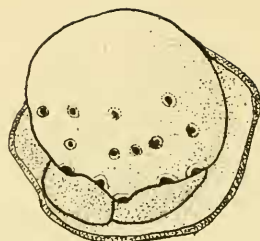
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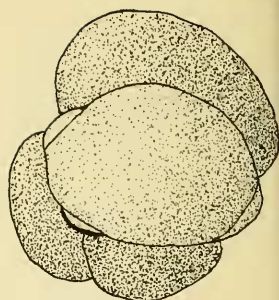
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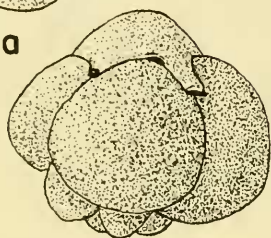
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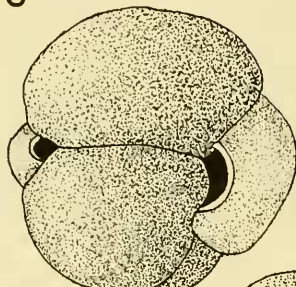
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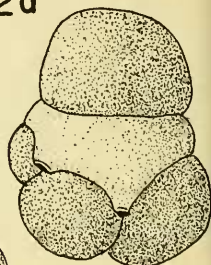
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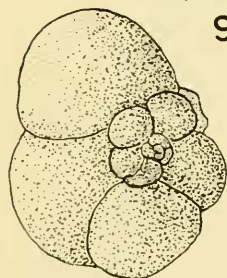
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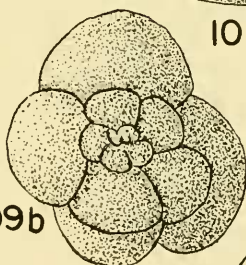
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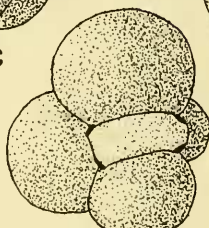
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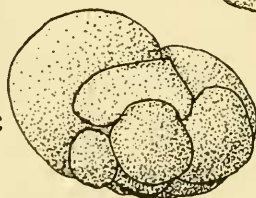
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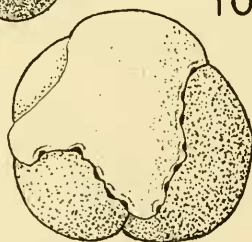
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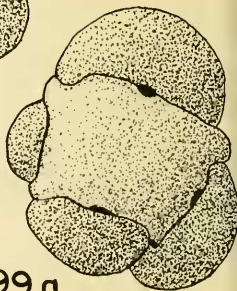
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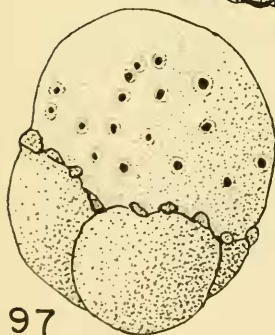
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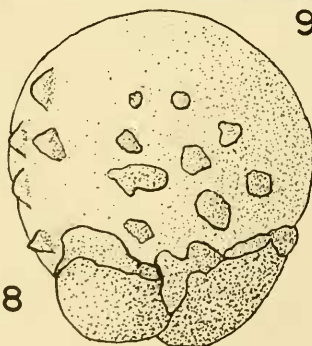
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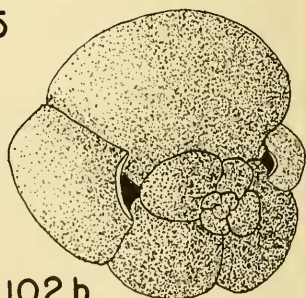
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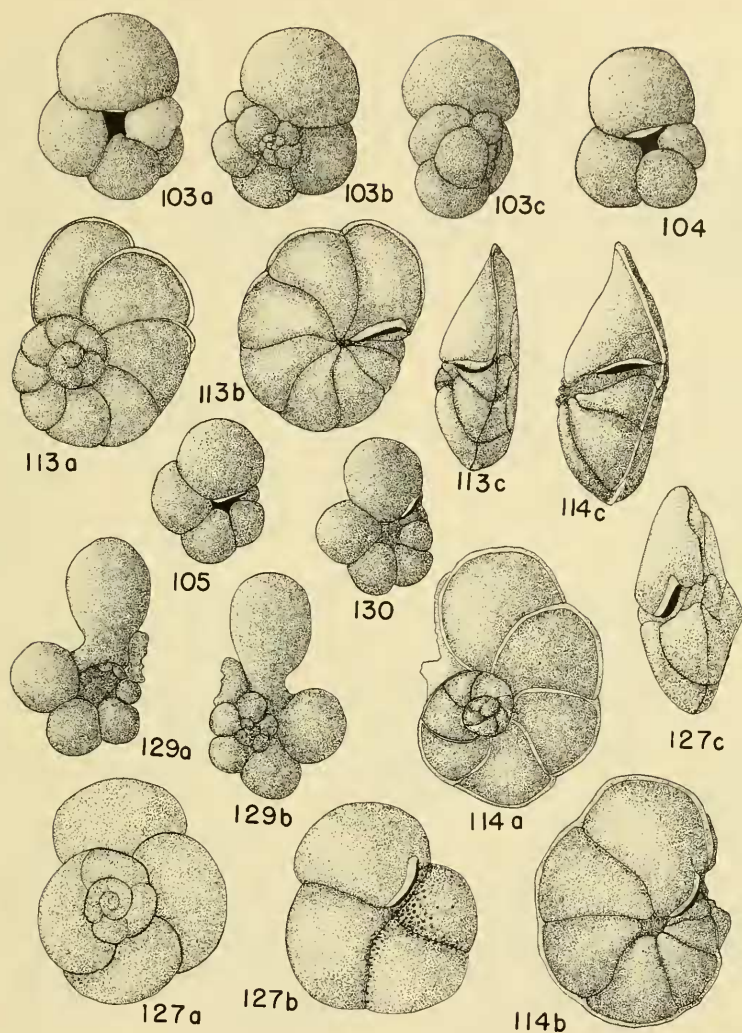
Explanation of Plate 15

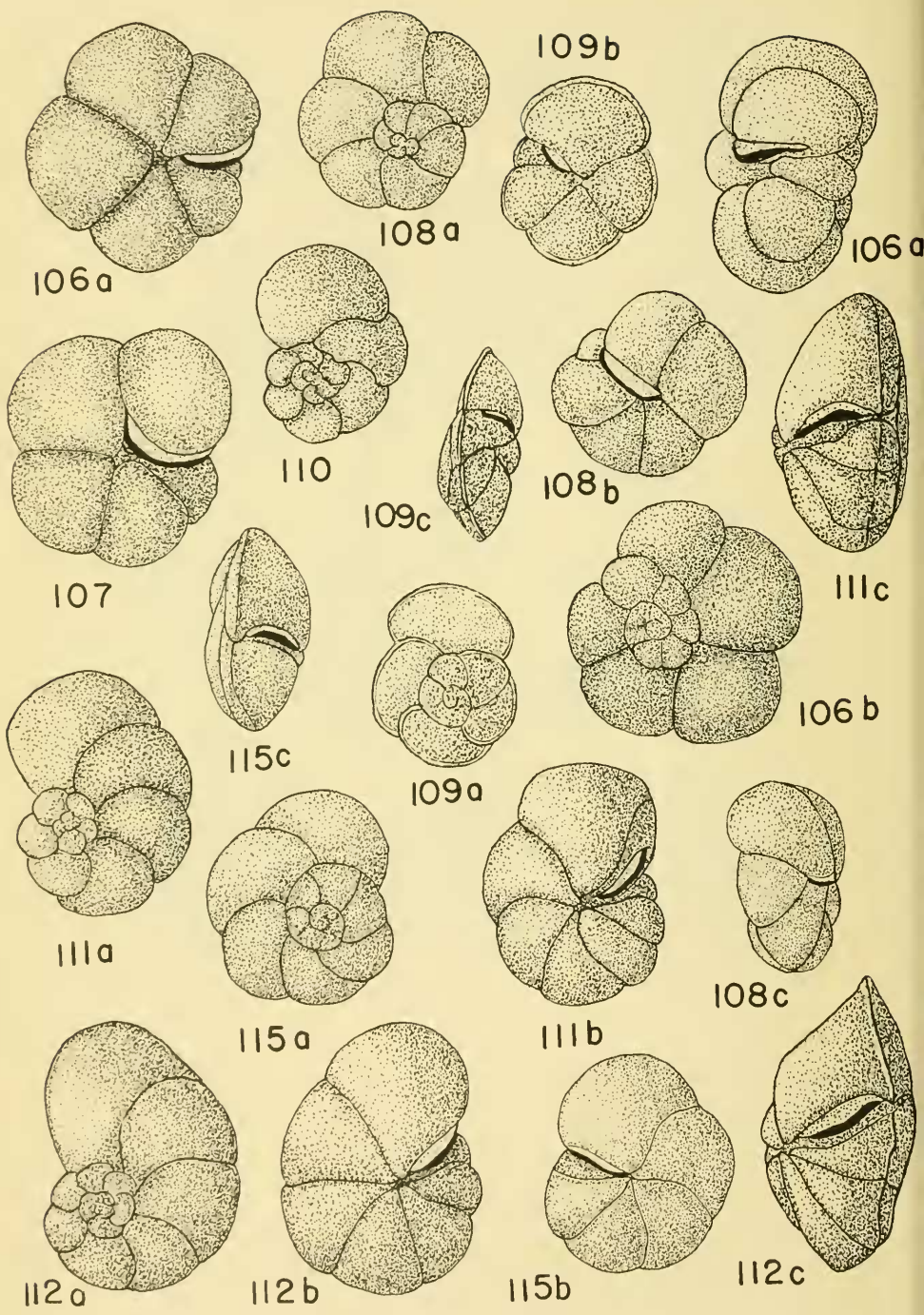
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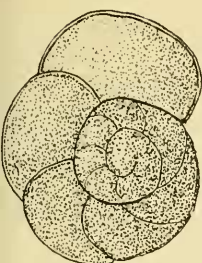
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(For figures 113, 114 see Plate 16.)

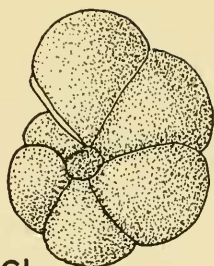
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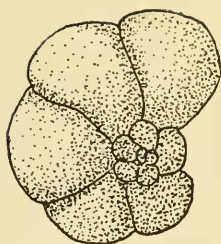
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117a



116b



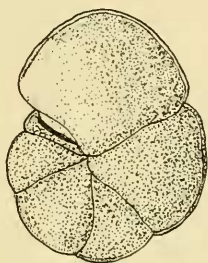
116a



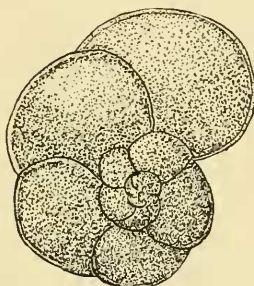
116c



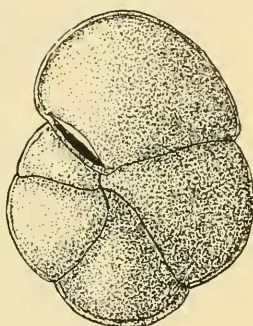
117c



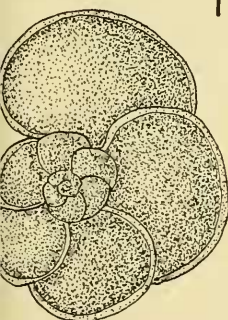
117b



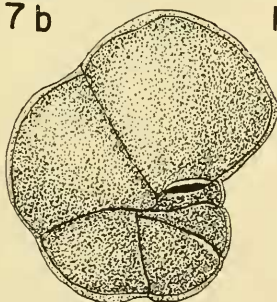
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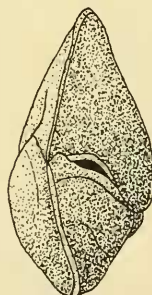
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119a



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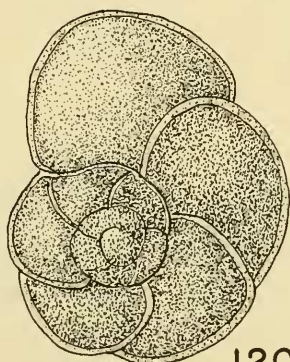
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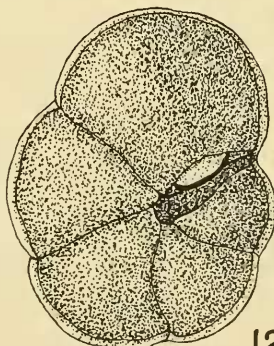
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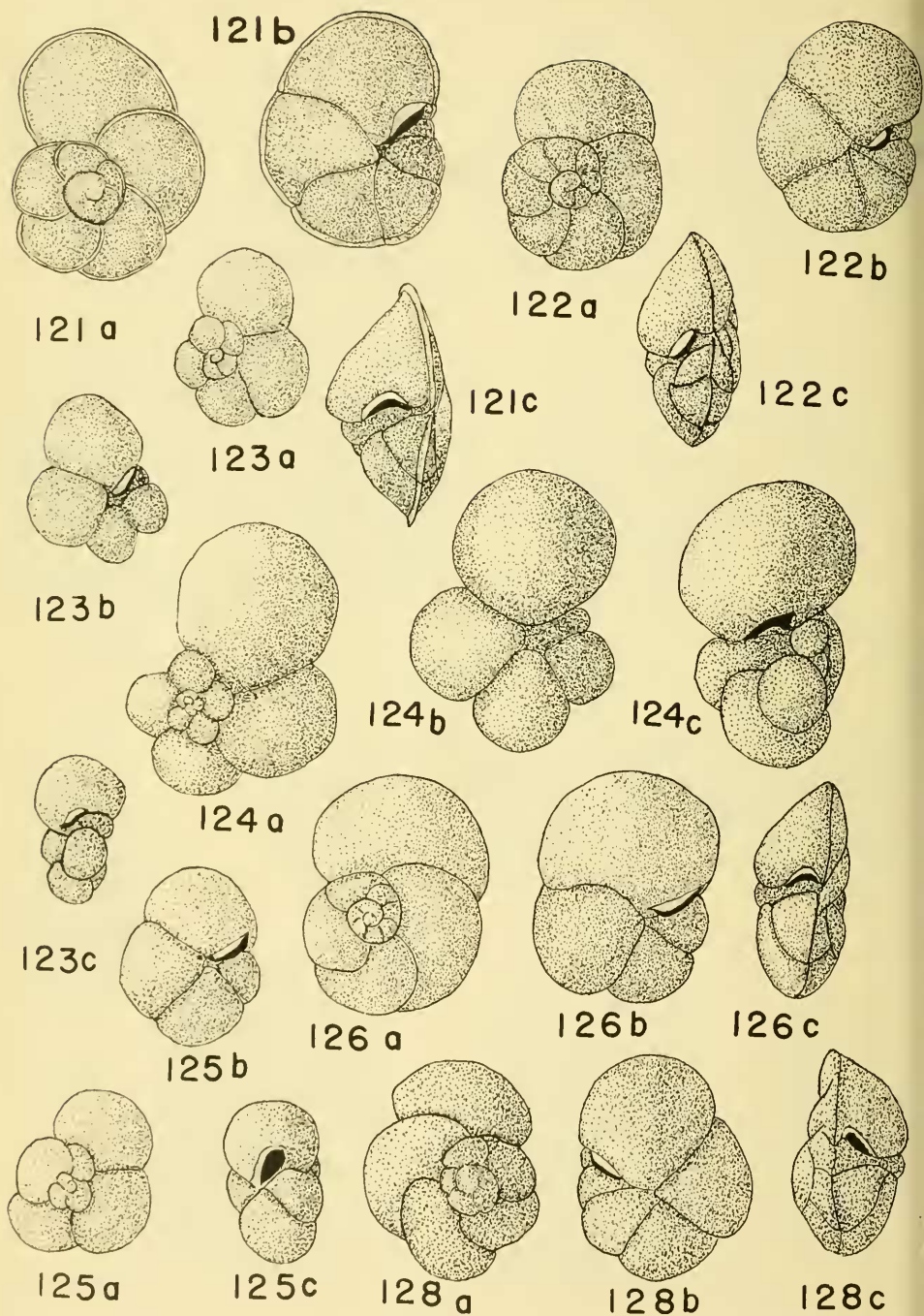
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## GENERA

*Globorotalia*

*Globoquadrino*

<i>Cotapsydrax</i>	<i>Globigerinatella</i>
	<i>Globigerinoida</i>
	<i>Globigerinita</i>

*Globigerina*

*Globigerinoides*

*Porticulusphaera* - Orbulina

Schere-delle

Hostigerino -  
Hostigerinello -  
Cossigerinello

RANGES OF THE PLANKTONIC FORAMINIFERA  
(with some suggested Phylogenies)

### CHART 3

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Note: The term San Lorenzo should be changed to Tucuyo.